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Provisional Medium Term Plan: 2010–2012 Challenge Program on Climate Change, Agriculture and Food Security (CCAFS)



CLIMATE
CHANGE
AGRICULTURE AND
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CCAFS Report No. 2

Provisional Medium Term Plan: 2010–2012 Challenge Program on Climate Change, Agriculture and Food Security (CCAFS)

July 2009

CCAFS is a Challenge Program of the Consultative Group on International Agricultural Research (CGIAR)

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Leaders had been sought, and an offer had been made to the preferred candidate for Director. Key contact points for each CGIAR institute and CP had been identified in order to establish good communications and effective planning by CCAFS and Alliance Centers/CPs. CCAFS is expected to be fully functional by November 2010.

Preface

This "provisional" Medium Term Plan (MTP) is so called because, at the time it was prepared, the Director was still to take up his/her position and the Theme Leaders (one for each MTP Project) were yet to be selected. The MTP is based on the initial proposal to the CGIAR. The MTP has been prepared at this early stage in line with the CCAFS Steering Committee's decision to align CCAFS planning procedures with CGIAR requirements at the earliest possible stage. As soon as the Director and Theme Leaders are appointed, there will be a strategic planning exercise which will give further consideration to the MTP. In particular, further attention will be given to elaborating on partners and impact pathways. It has been agreed for the purposes of the MTP, that the Themes described in the first CCAFS report (CCAFS, 2009), will be the MTP Projects, and this is the terminology used in this report.

A Challenge Program (CP) of the Consultative Group on International Agricultural Research (CGIAR) is a time-bound, independently-governed programme of high-impact research that targets the CGIAR goals in relation to complex issues of overwhelming global and/or regional significance, and requires partnerships among a wide range of institutions in order to deliver its products.

Exploratory discussions in 2007 between representatives from all 15 Alliance Centers and leading researchers from the global environmental change research community (under the auspices of the Earth System Science Partnership, ESSP) agreed to jointly prepare a proposal for a CP on issues relating to agriculture, food security and climate change. Following a detailed scoping exercise (which culminated in a successful pre-proposal for a CP), a Leadership Group comprising four CGIAR and four ESSP representatives prepared the final proposal.

This final version of the proposal was supported by the Chair of the Alliance Executive and the Chair of the ESSP Scientific Committee and incorporated early comments by the CGIAR Science Council and Executive Council. It was approved by the CGIAR Executive Council in May 2008 subject to CGIAR Science Council agreement of revisions. The CGIAR Science Council agreed to the revisions in September 2008.

As of July 2009, the Steering Committee (Appendix 4) of CCAFS had been established and had met once. Applications for the positions of Director and Theme

1. Introduction

Climate change represents an immediate and unprecedented threat to the food security of hundreds of millions of people who depend on small-scale agriculture for their livelihoods. At the same time, agriculture and related activities also contribute to climate change, by intensifying greenhouse gas (GHG) emission and altering the land surface. Responses aimed at adapting to climate change may have negative consequences for food security, just as measures taken to increase food security may exacerbate climate change. This complex and dynamic relationship between climate change, agriculture and food security is also influenced by wider factors. Agricultural and food systems are heavily influenced by socioeconomic conditions, which are affected by multiple processes such as macro-level economic policies, political conflict, the spread of infectious disease etc. A recent report by the World Economic Forum warns that "food security will become an increasingly complex political and economic problem over the next few years" (WEF, 2008).

1.1. Climate change and Earth system science

The Fourth Assessment (AR4) of the Intergovernmental Panel on Climate Change (IPCC) provides an overview of recent scientific understanding on climate change (IPCC, 2007). It brings together observations and modelling studies that confirm that human-induced temperature increases are taking place, with measurable and increasing effects on snow cover and ice caps, sea levels, precipitation patterns and tropical storm activity. It provides evidence of impacts of these changes on a range of systems around the world, including on marine and freshwater systems, on agriculture and on forests. Finally, it presents projections for climate change and its impacts under different scenarios over the coming decades.

There is a wealth of scenarios predicting how the global climate might change in the coming decades and over the next century. Although there are many uncertainties associated with these scenarios, it is becoming increasingly evident that regardless of mitigation efforts (undertaken today and in the future), temperatures will continue to increase over the next decades because of earlier emissions of greenhouse gases into the atmosphere. The

magnitude and frequency of extreme events are also set to increase over this period in many regions. Adaptation is therefore a necessary response to climate change. At the same time, mitigation of even further climate change is urgent if future changes are to be limited to levels that do not create irreversible environmental changes and devastate lives and livelihoods of the most vulnerable.


Climate, however, is only one factor within the dynamic Earth system. Changes in the physical and bio-geochemical environment, either caused naturally or influenced by human activities such as deforestation, fossil fuel consumption, urbanisation, land reclamation, agricultural intensification, freshwater extraction, fisheries over-exploitation and waste production, contribute to global environmental change (GEC). Earth system science takes a more holistic approach to understanding the processes and outcomes of GEC. It does this by including the interactions between land, atmosphere, water, ice, biosphere, society, technologies and economies. This approach seeks to understand the dynamics of climate change and the interactions with other types of environmental change, which together will have a great influence on food systems and food security¹.

1.2. The challenge for agriculture and food security

Agricultural and food systems are complex and dynamic. Some systems are less vulnerable to short-term climate effects (for example, where they are linked to irrigated farming systems fed by reservoirs of large storage capacity). Others, for example those relying on rain-fed agriculture, have always been exposed to uncertain and extreme climate but may now face variability beyond the current 'coping range'. In vulnerable systems, climate change threatens food security, livelihoods and economic prosperity (UNDP, 2007).

'Food systems' encompass (i) activities related to the production, processing, distribution, preparation and consumption of food; and (ii) the outcomes of these activities contributing to food security (food availability, with elements related to production, distribution and exchange; food access, with elements related to affordability, allocation and preference; and food use, with elements related to nutritional value, social value and food safety). The outcomes also contribute to environmental and other securities (e.g. income). Interactions between and within bio-geophysical and human environments influence both the activities and the outcomes (Eriksen, 2008).

'Food security' is the state achieved when food systems operate such that "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996). Food security is underpinned by food systems and is diminished when food systems are stressed. This stress can be caused by a range of factors in addition to global environmental change (e.g. population pressure, changes in international trade agreements and policies, migration) and may be particularly severe when these factors act in combination.



The AR4 has gathered scientific evidence and expert opinion on the expected impacts of climate change on agricultural systems (IPCC, 2007). The report notes that climate change is already having an impact, for instance, through changes in patterns of variability and associated changes in rainfall distribution. It anticipates with high confidence that projected changes in the frequency and severity of extreme climate events, together with increases in risks of fire and pests and pathogen outbreaks, will have significant consequences for food and forestry production, and food security. The impacts of projected changes in mean climate conditions are also expected to be negative. It identifies smallholder and subsistence farmers, pastoralists and fisherfolk as likely to be most vulnerable to the impacts of climate change.

The AR4 finds that Africa is highly vulnerable to climate change, because of multiple stresses and low adaptive capacity. Projections indicate an increase of arid and semi-arid land, and, in some countries, yield reductions in rain-fed agriculture of up to 50% by 2020; but some parts will also get wetter. In Asia, potential changes in the monsoon, and in glacier and snow melt are perhaps the greatest threats. Sea level rise is also of great concern as coastal and deltaic areas are often heavily populated and intensively cultivated. The natural and managed habitats of fish will be greatly influenced, with declining productivity in fisheries very likely. The report recognises that, despite a decade of research on climate change adaptation, considerable knowledge gaps remain, particularly concerning the adaptive capacity of food, fibre, forestry and fisheries systems.

Climate variability and risk has always been a part of agriculture, and farmers have developed many ways of managing that risk. Enhancing adaptation strategies is an important part of the work of the Alliance Centers. Developing drought-resistant and other abiotic stress-tolerant crop varieties, and soil and water management practices for marginal areas, for example, have long been core activities of the Alliance Centers. Climate change introduces a new dimension to the problem. The unprecedented rate and magnitude of climate change presents great challenges to farmers, researchers and policy-makers alike. The Alliance Centers have already begun to address the climate change challenge. All have incorporated activities on climate change impact analysis, mitigation options or adaptation strategies into their research priorities and programmes, and several Centers have recently established dedicated programmes on climate change. (Some of this work was highlighted in a 2008 article on SciDevNet, which describes how researchers are working to 'climate-proof' crops, and the key role of biodiversity in this effort, and a special issue of *Agriculture, Ecosystems and Environment* (Verchot and Cooper, 2008), which highlights various aspects of CGIAR climate change-related science.) However, this research has not been carried out or brought together in an integrated way that highlights the interactions, synergies

and trade-offs between different actions and responses to climate change.

Current efforts to increase adaptation options provide a sound basis for the next phase of research on climate change, agriculture and food security. However, this phase must go far beyond what is currently being done. New responses are needed, as well as new ways of working. These must be instilled with a degree of urgency, reflected in the research agenda, its implementation, and in the delivery of outputs.

2. CCAFS context

2.1. The need for research and new partnerships

Concerted action is urgently needed to address the complex challenges of climate change and its impact on agriculture and food security. Likewise, the effects of agriculture and natural resource management on the climate system should receive additional attention. A new research initiative is needed to inform action – one that integrates and applies the best and most promising approaches, tools and technologies emerging from numerous disciplines. The involvement of farmers (both women and men), policy-makers, researchers, donors and other stakeholder groups in the research process is key. Successful mitigation and adaptation will entail not only individual behavioural changes, but also changes in technology, institutions, agricultural systems and socioeconomic systems. These changes cannot be achieved without improving interactions between scientists and decision-makers at all levels of society.

The CGIAR Challenge Program on Climate Change, Agriculture and Food Security (CCAFS) proposes a new strategic collaboration between the CGIAR Centers and the Earth System Science Partnership (ESSP) (Box 1). This alliance, and its partners, brings together the world's best researchers in agricultural science, climate science and Earth system science to identify and address the most important interactions, synergies and trade-offs between climate change, agriculture and food security. CCAFS will thus define and implement a uniquely innovative and transformative research programme that addresses food security in the context of climate variability, climate change and uncertainty about future climate conditions.

Although climate change is a long-term phenomenon, the actions taken over the next 10 years will be critical. The foundations must be set for responsive, adaptive agricultural technologies and policies that help people reduce their vulnerability to climate variability, while at the same time paving the way for the successful management of long-term changes.

Box 1. Earth System Science Partnership (ESSP)

The ESSP was established in 2001 to promote cooperation for the integrated study of the Earth system, the changes that are occurring to the system and the implications of these changes for global sustainability. The ESSP comprises four international global environmental change research programmes: DIVERSITAS, specialising in biodiversity and agro-biodiversity; the International Human Dimensions Programme on Global Environmental Change (IHDP), specialising in institutional, socioeconomic and human security issues related to global environmental change and the policies to address it; the International Geosphere–Biosphere Programme (IGBP), specialising in the physical, chemical and biological processes that define Earth system dynamics; and the World Climate Research Programme (WCRP), specialising in climate science.

2.2. The Challenge Program

This Challenge Program provides a framework to facilitate new research on the interactions between climate change, agriculture and food security. It introduces a new partnership between the international agricultural research and Earth systems science communities which will create unique possibilities in the search for solutions to the climate change/food security problem. Research will build on the ongoing activities of both communities, but will go beyond core centre research or what is feasible under a system-wide programme within the CGIAR, by opening new avenues of interaction and synergy that will prove to be essential in tackling this most complex and urgent of global challenges:

- Emerging avenues for adapting to a changing climate that are currently constrained by major knowledge gaps and that, because of their newness, have not yet been fully explored or mainstreamed within the CGIAR.
- Adaptation and mitigation interventions that require upstream research capacity (particularly climate, Earth systems and global change science) beyond the CGIAR's core expertise to achieve their full potential.
- Opportunities for adaptation and mitigation that require the involvement of downstream institutions (e.g. global and regional climate centres, national meteorological services, food crisis early warning and response systems) beyond the CGIAR's traditional partners.
- Robust analytical approaches and tools that will enable the CGIAR to better target technology and policy for the range of possible future climate realisations, and assess potential impacts *ex-ante*.
- Integrated approaches to adapting agriculture and food systems to a changing climate that depend on the coordination, integration and economy of scale that a Challenge Program can provide.

By producing international public goods (IPGs) that will help protect and enhance progress towards achieving sustainable food security and reducing poverty in developing countries, in the face of new and intensified challenges imposed by a changing climate, CCAFS contributes directly to the CGIAR's mission. All CCAFS Projects (known as Themes in the first CCAFS report, CCAFS, 2009) address generic issues and will develop tools that are relevant beyond the scope of the initial target regions. The selected regions encompass numerous biophysical and socioeconomic characteristics of climate change effects that are analogous to other regions of the developing world. Likewise, the scenarios that will be examined incorporate universal response pathways and, thus, could be used as prototypes within other regional contexts. Modelling tools can be validated and used for other areas as well as for up-scaling of, for example food production and GHG emissions.

Several innovative approaches distinguish CCAFS from other ongoing work. First, it will work at multiple spatial scales to address the often cross-scale interactions between climate and food and agricultural systems. The CCAFS targets scale up to sub-continental because (i) significant climate perturbations, and appropriate adaptation responses, may be experienced at this scale; (ii) environmental issues, and their solutions, often cross national boundaries; (iii) food system interventions related to intra-regional trade and distribution, and agricultural labour movements, are realised at this scale; and (iv) existing sub-regional organisations (i.e. CORAF/WECAEC, ASARECA and the RWC) provide a mechanism for coordinating national research at the regional level and scaling-up implementation; and (v) donors often plan at the regional scale and are usually keen to support regional structures.

Second, it will work across time scales, seeking to identify and develop the knowledge base and capacity for immediate actions that allow current development to sustain and prosper in the face of a changing climate. Research on adapting to climate includes management of current climate risk, and adaptation to progressive climate change anticipated over the coming decades. Similarly, work on mitigation addresses emerging mechanisms that provide immediate livelihood benefits, while reducing the GHG burden and protecting and enhancing environmental services for the future.

Third, it will emphasise the characterisation and management of uncertainty. Uncertainty is a fundamental challenge when dealing with climate at all time scales. CCAFS will go beyond simple multi-model climate change scenarios to better characterise climatic uncertainty, and provide a rigorous framework and analytical infrastructure for developing adaptation responses that are robust in the face of uncertainty at all relevant time scales.

Fourth, it will focus on several emerging and innovative adaptation opportunities that have not yet been fully

exploited, and whose potential is only partially understood. Examples include new ways to use new climate information products and services, index-based financial risk transfer products, opportunities from climate policy and carbon certification, climate-informed management of food trade and delivery systems, and management of climate-driven spatial shifts of agro-ecosystems.

Finally, it is integrative. Building on the substantial work on 'component' adaptation technologies developed by the CGIAR, its partners and its stakeholder participants, it will design and assess integrated portfolios of adaptation and mitigation interventions, with a focus on livelihoods and food security at household and higher levels. In between the paradigms of 'planned' adaptation to a known change and the 'risk reduction by diversity' approach to increased uncertainty, it will explore 'planned diversity' and 'diversity of plans', as elements of a higher order risk management strategy.

2.3. Goal and objectives of CCAFS

The overall goal of CCAFS is

- To overcome the additional threats posed by a changing climate to achieving food security, enhancing livelihoods and improving environmental management.

CCAFS will address this goal by generating the knowledge base and toolsets to empower and assist farmers (both men and women), policy-makers, researchers and donors to successfully manage agricultural and food systems so as to strengthen food security, enhance rural livelihoods and improve environmental sustainability in the context of the challenges arising from current climate variability and progressive climate change.

The three objectives of CCAFS are:

1. To close critical gaps in knowledge of how to enhance – and manage the trade-offs between – food security, livelihood and environmental goals in the face of a changing climate.
2. To develop and evaluate options for adapting to a changing climate to inform agricultural development, food security policy and donor investment strategies.
3. To enable and assist farmers, policy-makers, researchers and donors to continually monitor, assess and adjust their actions in response to observed and anticipated changes in climate.

Objective 1 is geared towards outputs; Objective 2 is geared towards outcomes; Objective 3 is geared towards impacts.

3. Highlights of the 2010–2012 MTP Project Portfolio

3.1. Project Portfolio

The 2010–2012 MTP lays out an array of six Projects. These are grouped into two sets.

Set 1: Diagnosis and developing the knowledge base: setting the research context and ex-ante analysis of trade-offs between improving livelihoods, food security and environmental benefits

- Project 1: Diagnosing vulnerability and analysing opportunities
- Project 2: Unlocking the potential of macro-level policies
- Project 3: Enhancing engagement and communication for decision-making

The first three Projects provide an essential foundation in the form of a strong analytical and diagnostic framework, grounded in the global change policy environment, and know-how to effectively engage rural communities and institutional and policy stakeholders. Targeting food security, poverty reduction and sustainable natural resource management interventions that are robust in the face of a changing and uncertain climate requires a strong *ex-ante* analytical capacity to diagnose points of vulnerability, and assess the impacts and trade-offs between socioeconomic and environmental goals associated with alternative strategies. The global policy environment increasingly influences the opportunities and constraints to local and national-scale actions that can be taken in response to a changing climate and, in some cases, may be responsive to evidence obtained from the type of research that CCAFS will undertake. Understanding vulnerability, identifying appropriate interventions, assessing their effectiveness, and leaving a sustained legacy of improved decision-making all depend critically on effective modes of engagement with a range of stakeholders.

Set 2: Developing adaptation pathways and identifying mitigation options for agricultural and food systems in the face of climate change

- Project 4: Adaptation pathways based on managing current climate risk
- Project 5: Adaptation pathways under progressive climate change
- Project 6: Poverty alleviation through climate change mitigation

The 'Adaptation' set of Projects will identify and develop instruments, technologies, practices and partnerships needed to decrease the vulnerability of rural communities to a variable and changing climate. The three Projects involve different interventions that build on distinct bodies of knowledge and require the involvement of different institutions. These Projects have been designed to develop outcomes achievable from the added-value of a CGIAR–ESSP collaboration. Research in these three Projects will build on the ongoing core work of the Alliance Centers; on advances in knowledge of the global climate system, of management of climate risk and adaptation to climate change; and on the knowledge and methodology developed in the first set of Projects.

Collectively, these three Projects will demonstrate and assess the feasibility, effectiveness and acceptability of integrated strategies for advancing food security, livelihood and environmental goals in the face of a changing climate; and will identify and prioritise institutional and policy options for overcoming obstacles to implementing these strategies at the scale of the development challenge. The process of addressing these questions in the research regions will enhance capacity (in the form of analytical tools and infrastructure) to better target and evaluate a range of adaptation and mitigation options.

3.2. Portfolio composition and cross-Project integration

The CCAFS Project Portfolio is presented in more detail in Table 1. This Project Portfolio will build on CCAFS's comparative advantage, the combination of CGIAR and ESSP strengths. CCAFS will ensure that each problem is addressed through appropriate inter-disciplinary research expertise.

The six Projects are interdependent. For example, the adaptation set (Projects 4–6) depends on tools, methods and knowledge outputs developed in Projects 1–3. Several cross-Project research activities have been identified. Wherever feasible, Projects 4–6 will share common benchmark sites and regional research infrastructure. The

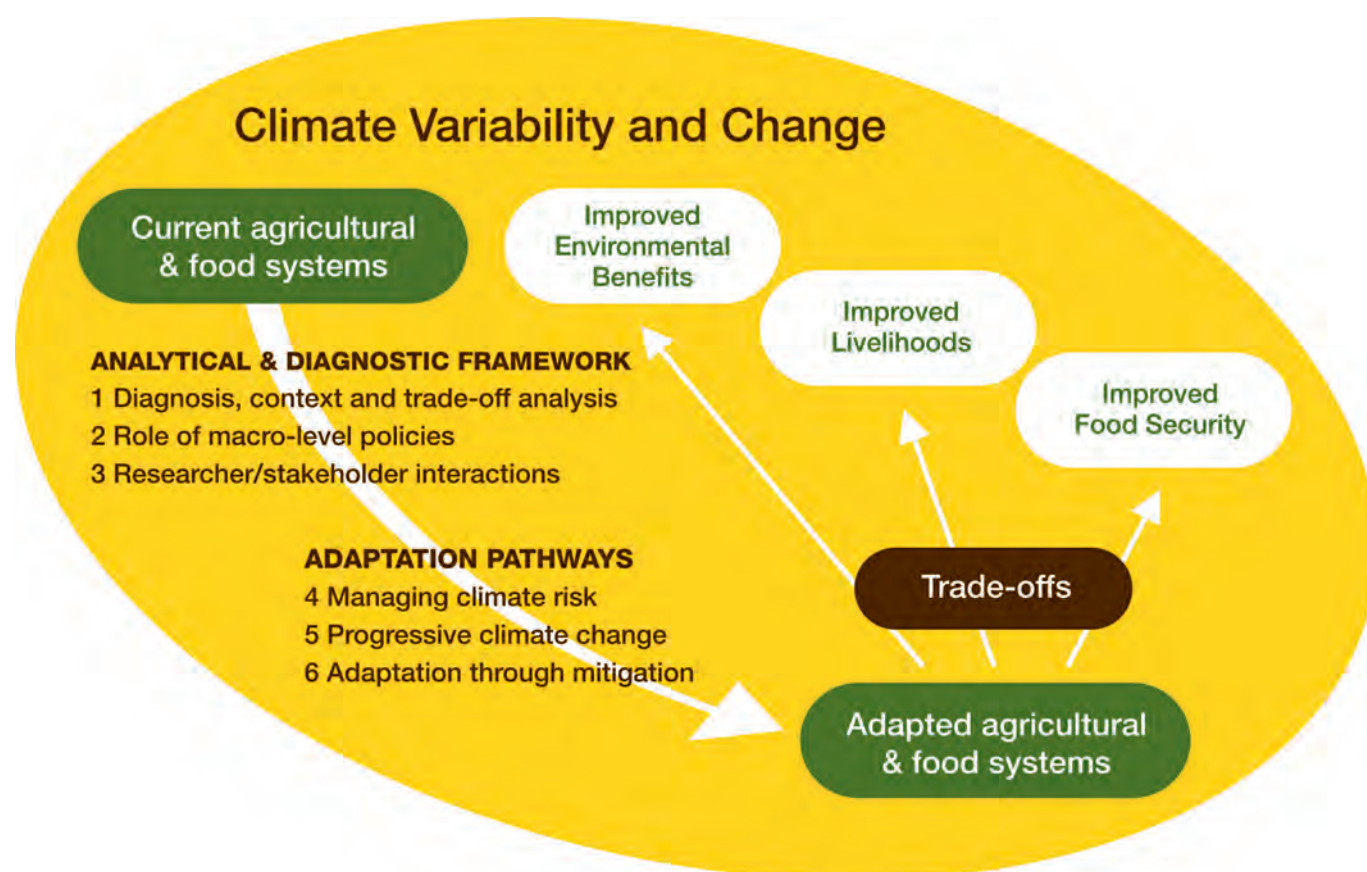


Figure 1. Schematic presentation of the CCAFS research framework and the Science Projects.

Management Team will consider opportunities for synergies across Projects in determining the scope of commissioned and competitive research. The Management Team will also be responsible for ensuring that work within Projects is coordinated and synthesised across CCAFS, and produces IPGs.

Annual CCAFS synthesis workshops will be held immediately following a set of Project synthesis workshops (to be held concurrently) to recap, distil and add value to outputs from research activities within each Project, and to synthesise knowledge across the Projects. Where feasible, these workshops will be held in focus regions to both bring in local participants and strengthen S-S partnerships. The Steering Committee, in consultation with the Management Team, may adjust the frequency, scope and venue of the workshops as needed.

The "Verifiable Indicators of Output Targets" column in the MTP Logframe (Appendix 1) identifies cross-Project activities and milestones for cross-Project collaborative work. In particular, Project 1 Output 1, the development of scenarios for the target regions, will draw on data and insights derived from all the Projects.

3.3. Alignment with CGIAR System Priorities

The CGIAR Science Council (2005) set out 20 research priorities for the CGIAR, organised within five priority areas. Figure 2 maps key direct and indirect contributions of the six CCAFS Projects in relation to these System Priorities (further details are provided in Project Narratives). CCAFS is expected to contribute in various ways to these System Priorities, as described below.

Priority area 1, Sustaining biodiversity for current and future generations. The work will indirectly contribute to 1a, *Conservation and characterisation of staple crops*; 1b, *Promoting conservation and characterisation of under-utilised plant genetic resources to increase the income of the poor*; and 1c, *Conservation of indigenous livestock*, mostly via diagnosis and *ex-ante* assessment of the various adaptation pathways and different roles that plants and animals with different characteristics can make to livelihoods, food security, and environmental sustainability.

Table 1. CCAFS Project Portfolio 2010–2012.

Project Title	Options
Project 1. Diagnosing vulnerability and analysing opportunities	<p>1.1. Establishment, through scenario analysis, of a coherent set of scenarios that examine potential development scenarios under a changing climate and differing pathways of economic development</p> <p>1.2. Identification of climate trends and variability, and assessment of methods for downscaling climate change information for agriculture and natural resources management</p> <p>1.3. Integrated assessment framework and toolkit to enhance capability to assess climate change impacts on agricultural systems and their supporting natural resources, and analysis of likely effects of specific adaptation and mitigation options</p>
Project 2. Unlocking the potential of macro-level policies	<p>2.1. Improved approaches, tools and databases for assessing the impacts of macro-level policies on adaptation and mitigation strategies</p> <p>2.2. Recommendations for macro-level policies that provide opportunities for adaptation and mitigation strategies</p>
Project 3. Enhancing engagement and communication for decision-making	<p>3.1. Identification of key actors, their information needs and the institutional and decision-making context for uptake of policy recommendations and technical practices for adaptation and mitigation</p> <p>3.2. Tools, guidelines and approaches that enhance researcher–stakeholder interaction and the uptake of scientific outputs, including from CCAFS</p>
Project 4. Adaptation pathways based on managing current climate risk	<p>4.1. Identification of crop cultivar and rural livelihood portfolios that buffer against climate shocks and enhance livelihood resilience</p> <p>4.2. Analysis and evaluation of index-based risk transfer products to protect and enhance rural livelihoods</p> <p>4.3. Identification of improved modalities and approaches for managing climate risk through the food storage, trade and distribution system</p>
Project 5. Adaptation pathways under progressive climate change	<p>5.1. Analysis and modelling of potential best natural resource management practices under changed climatic conditions</p> <p>5.2. Improved methods, approaches and technologies for ensuring crop varietal fit to scenarios of variability and change</p> <p>5.3. Identification of holistic adaptation strategies that can be taken up in the face of progressive climate change</p>
Project 6. Poverty alleviation through climate change mitigation	<p>6.1. Improved tools, models and technologies to enhance climate change mitigation by the rural poor</p> <p>6.2. Identification of market-based instruments and other institutional arrangements that improve the uptake of mitigation strategies that benefit the poor</p> <p>6.3. Tools, models and principles to enhance understanding of the trade-offs and synergies between mitigation and adaptation; and among the goals of environmental sustainability, reduced emissions and livelihood improvement</p>

In particular, Project 5 will contribute directly to 1a, *Conservation and characterisation of staple crops* through work on climate-driven shifts in adaptation zones of crop wild relatives.

Priority area 2, Producing more and better food at lower cost through genetic improvements. CCAFS will contribute to this priority area primarily through enhanced climate information and analytical tools and stakeholder interactions to better target the development of appropriate germplasm to achieve these aims in the context of current climate variability and future climate change. Projects 1, 4 and 5 will directly address 2a, *Maintaining and enhancing yields and yield potential of food staples* and 2b, *Tolerance to selected abiotic stresses*, in relation to vulnerability assessment and identification of options (Project 1) and both long- and short-term adaptation pathways (Projects 4 and 5).

Priority area 3, Reducing rural poverty through agricultural diversification and emerging opportunities for high-value commodities and products. CCAFS will contribute indirectly to this priority by evaluating and fostering diversified livelihood strategies for managing climate risk. Within this priority area, adaptation pathways are most likely to contribute to 3b, *Income increases from livestock* and 3d, *Sustainable income generation from forests and trees*, in relation to the assessment and implementation of adaptation pathway options that can benefit livelihoods and spread risks.

Priority area 4, Poverty alleviation and sustainable management of water, land, and forest resources. CCAFS will directly address 4a, *Integrated land, water, and forest management at landscape level*, through Projects 2, 3, 4, 5 and 6. This is a cross-cutting research area for all CCAFS Projects. This System Priority is the main one for Project 6. CCAFS will also directly address 4c, *Improving water productivity*, especially through Projects 3 and 4. CCAFS will also contribute to 4d, *Sustainable agro-ecological intensification in low- and high-potential areas* by exploring the potential to reduce dependence on rain-fed subsistence cereal-based agriculture, which is highly sensitive to climate shocks (Project 1), and by addressing climate risk as a disincentive to adoption of innovation and appropriate intensification.

Priority area 5, Improving policies and facilitating institutional innovation to support sustainable reduction of poverty and hunger. A key feature of the CCAFS is the integration of policy work and stakeholder interactions, and it will contribute directly to 5a, *Science and technology policies and institutions* (Projects 2, 3 and 4); to 5b, *Making international and domestic markets work for the poor* (Projects 2 and 4); to 5c, *Rural institutions and their governance* (Project 6); and to 5d, *Improving research and development options to reduce rural poverty and vulnerability* (Projects 2, 3 and 4), in relation to system

characterisation and the policy and institutional context within which adaptation pathways will need to be implemented.

Each Output in the MTP has to be allocated to a single System Priority (SP), as per CGIAR instructions. If this is done, then in budgetary terms for 2010 most of the CCAFS portfolio falls under SP 5D, "Improving Research and Development Options to Reduce Rural Poverty and Vulnerability", 4A, "Integrated Land, Water and Forest Management at a Landscape Level", and SP 4D, "Sustainable agro-ecological intensification in low and high potential environments" (Figure 3). Other foci are 2A, "Maintaining and Enhancing Yields and Yield Potential of Food Staples", and 5A, "Science and Technology Policy and Institutions".

Priority Area 1	Priority Area 2	Priority Area 3	Priority Area 4	Priority Area 5
Sustaining biodiversity	Genetic improvements	Diversification and high value commodities	Integrated NR management	Policies and institutional innovation
1A: Conservation of PGR for food and agriculture ● ● ●	2A: Maintaining and enhancing yield of staples ● ● ● ●	3A: Income increases from fruit and vegetables ● ●	4A: Integrated land, water, forest management at landscape level ● ● ● ● ● ●	5A: Income increases from fruit and vegetables ● ● ● ● ● ●
1B: Promoting conservation/characterisation of UPR for income ● ● ●	2B: Tolerance to abiotic stresses ● ● ● ●	3B: Income increases from livestock ● ● ● ●	4B: Sustaining aquatic ecosystems for food and livelihood ● ● ● ● ● ●	5B: Making international and domestic markets work for the poor ● ● ● ●
1C: Conservation of indigenous livestock ● ● ●	2C: Enhancing nutritional quality and safety ● ● ● ●	3C: Enhancing incomes through production of fish and aquaculture ● ● ● ●	4C: Improving water productivity ● ● ● ● ● ●	5C: Rural institutions and their governance ● ● ● ● ● ●
1D: Conservation of aquatic animal genetic resources ● ● ●	2D: Genetic enhancement of high value species ● ● ●	3D: Sustainable income from forests and trees ● ● ● ● ● ●	4D: Agro-ecological intensification in low-/high- potential areas ● ● ● ● ●	5D: Improving research and development options to reduce rural poverty and vulnerability ● ● ● ● ●

- 1 Diagnosing vulnerability
- 2 Unlocking the potential of macro-level policies
- 3 Enhancing researcher–stakeholder interactions
- 4 Adaptation pathways: current climate risk
- 5 Adaptation pathways: progressive climate change
- 6 Emerging mitigation options

Figure 2. Contribution of CCAFS to the CGIAR System Priorities, by Project. Examples of direct (circles) and indirect (semicircles) contributions.

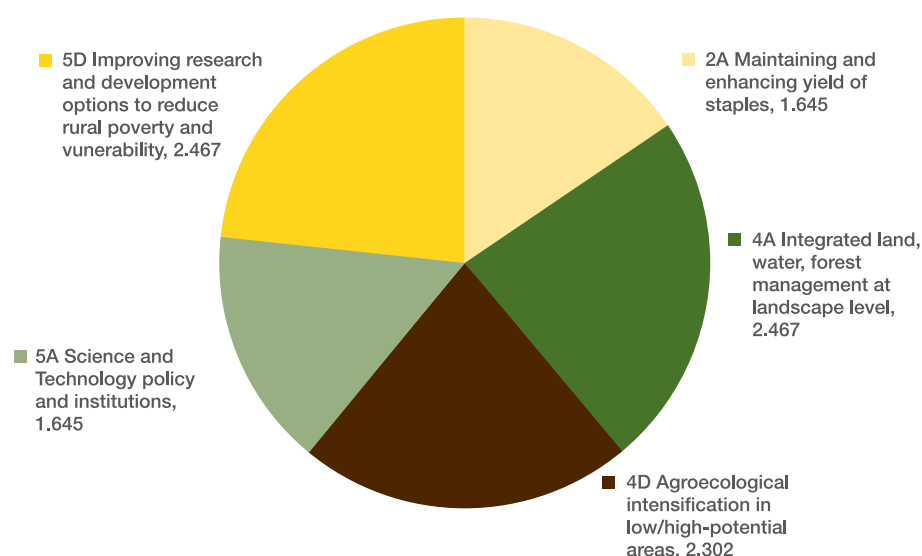


Figure 3. Proportions of proposed CCAFS 2010 budget that will be expended on CGIAR System Priorities (US \$ million).

4. Partnerships, gender mainstreaming and capacity building

Partnerships are key to the implementation of CCAFS. The Challenge Program will have a very small secretariat. The research will be conducted by individuals in partner institutions. Collaboration will bring together the best agricultural, climate and Earth system science; will be positioned to critically assess and advance the state of science, methodology and technology; will enhance N-S, S-N and S-S capacity building; and will ensure that CCAFS strengthens science-policy interfaces.

4.1. Partnerships with Alliance Centers and other Challenge Programs

The CCAFS CP has been designed as a cross-centre collaborative programme in which Alliance Centers are integral to the implementation of the research. The Alliance Centers bring numerous strengths to the CGIAR-ESSP partnership, in particular: experience with modelling farming systems and evaluating how agricultural, forestry and land management options can impact on the livelihoods of poor farmers, herders, fishers and women within a dynamic market and policy environment; experience with genetic enhancement; experience with farmer participatory research; and experience in agricultural by-products with potential for bio-energy generation.

It is expected that at least half of the Theme Leaders will be based at Alliance Centers, and that the Regional Facilitators will also be based at Alliance Centers. To put the CGIAR-ESSP collaboration on a sound footing, a strategic planning exercise will be conducted as soon as CCAFS is operational. The following target outputs/milestones are scheduled to be delivered in 2010: (i) Strategic framework for plant-breeding institutions (such as the GCP and commodity-based CGIAR Centers) that addresses joint research planning for genetic enhancement of principal food crops in target regions to deal with projected climate change stresses; (ii) Research network of CGIAR Centers, their partners and other agricultural stakeholders working to better target, develop, and update adaptation technologies.

Links with other CPs will include, *inter alia*: joint characterisation of Target Populations of Environments (TPEs) for targeting germplasm and adapting crop improvement strategies to climate variability and change with the Generation CP, and through the establishment of an inter-CP working group advising on: methodology; joint water management and governance studies in the Indo-Gangetic Plains with the Water and Food CP; and the possibility of sharing research sites with the Sub-Saharan Africa CP.

The CCAFS Steering Committee includes a representative from the CGIAR Alliance (*ex officio*).

4.2. Partnership with ESSP

The CGIAR-ESSP collaboration will go beyond the traditional disciplinary science and allow a truly integrated multi-disciplinary, resilience-based approach to the climate change-food security problem. This means a focus on key drivers, possible non-linear and threshold responses, interactions of biophysical and socioeconomic factors across scales, and possible socioeconomic responses.

ESSP brings to the table the climate modelling tools for generating future climate scenarios critical for assessing climate change adaptation and mitigation strategies, and broad knowledge and experience in data and models of land use and how land management decisions impact on the Earth system dimensions of climate, water resources, biodiversity, and soils. It also brings expertise in remote sensing, bio-geochemical cycles, hydrology, land degradation, function and valuation of biodiversity, and the social and political dimensions of vulnerability and adaptive capacity.

Collaboration between the two communities will allow for better climate change projections including land surface feedbacks on climate particularly in relation to agricultural activities, geographically explicit analysis of potential productivity, tools for full carbon/water/nutrients accounting, and valuation of biodiversity and other ecosystem services. It will also identify the situations where both global and local environmental benefits can be attained based on improved understanding of feedbacks to the Earth system, whilst also generating income and strengthening rural livelihood strategies. It will combine available knowledge and skills (e.g. modelling) unique to ESSP regarding global and regional climate change with CGIAR long-term, on-the-ground expertise in agro-ecosystems of the developing world and large research-for-development networks. It will combine ESSP expertise on agro-biodiversity management (agro-ecosystem services, biodiversity integration, soil biology, conservation agriculture, trade-off valuation (farmer income vs. benefits to society), and participatory approaches) and sustainability assessment (e.g. DIVERSITAS) with CGIAR's 'heartland' research on germplasm banks, genetic enhancement of

crops and animals (including fish), integrated pest management, and crop livestock systems.

The CCAFS Steering Committee will include a representative from the ESSP Scientific Committee (*ex officio*).

4.3. Collaboration with Advanced Research Institutes

The innovative collaboration between the CGIAR Centers and the ESSP, and their respective partners, will form the backbone of other strategic international partnerships. Several ARIs have expressed an interest in, and have contributed to the development of, CCAFS. These include the many institutions mentioned in the pre-proposal as well as others, for example, AGROPOLIS. These new partnerships will be established and/or strengthened in the first year of operation of CCAFS, capitalising on the innovative agenda.

4.4. CCAFS in international policy arenas

A few dozen international organisations and processes will exert much influence on how climate change adaptation and mitigation strategies unfold globally. In its first months of operation, CCAFS will strategise on the priority actors, at the global level, that the research efforts must reach, and will lay out in detail how the engagement will be managed and implemented. The actors include: the World Bank, the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UNREDD) the Food and Agriculture Organization of the United Nations (FAO), the World Food Program (WFP), the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP). Some specific bilateral donors will also play a major role through their support programmes to developing countries and their influence on international processes.

4.5. Host country collaboration

The CCAFS Director and Secretariat will be hosted by the University of Copenhagen, and in particular by the Department of Agriculture and Ecology in the Faculty of Life Sciences (LIFE). The University has offered to host CCAFS under an agreement that includes the provision of basic services without any overhead charge. In addition, the Secretariat will receive major support through a grant from DANIDA.

Based on offers received after a call was sent out, the host institute was selected by the Steering Committee on the basis of a number of criteria that included the ability to provide: (i) financial, legal, human resources and office functions to the CCAFS; (ii) a conducive scientific environment for CCAFS staff; (iii) telecommunications with the rest of the world (telephone, internet, teleconferences) that are easy to use, totally reliable and cost-effective; (iv) a geographical location such that travel costs to the different sites where the work will be implemented and to the different partner institutions are kept to a minimum; (v) cost-effective administrative support to the CCAFS; (vi) a suitable staff member to represent the institution on the Management Committee of CCAFS; (vii) a cost-effective, non-bureaucratic, transparent host institution agreement with CCAFS, which covers all the above dimensions of hosting; (viii) a location that allows for strong and frequent links with donors.

The hosting agreement between the Alliance and University of Copenhagen should be signed in mid-2009.

4.6. Regional research hubs and collaboration with NARS

CCAFS design is based on six Science Projects to be researched collaboratively by CGIAR–NARS–ESSP teams working closely with their respective partners and with stakeholders. NARS partners are expected to be drawn from agriculture research institutions, meteorological services and the university sector.

The Projects will be primarily researched in a number of regions. The three initial focus regions are Eastern Africa, West Africa and the Indo-Gangetic Plains (IGP). Research outputs will be *integrated across Projects within regions* to provide regional public goods (RPGs) and other benefits to the given region. Strategic S–S partnerships will be established based on the opportunities for Project synthesis across the diversity of research regions.

Research within focus regions will target scales ranging from field to sub-regions. Research that must be addressed at the field, farm and community scales in each region will be conducted across a set of research locations representing relevant biophysical and socioeconomic gradients. These 'benchmark sites' will be selected by regional science/stakeholder groups coordinated by CCAFS Regional Facilitators, and in close consultation with Theme Leaders. A key aspect will be to build on ongoing CGIAR and national research infrastructure and research sites, and existing data, rather than establishing CCAFS research sites *de novo*.

Research in each region will be facilitated by CCAFS Regional Facilitators based in CGIAR institutions with regional mandates, namely at the offices of the Regional

Alliance Collective Action Network in West and Eastern Africa, respectively, and at the Rice-Wheat Consortium.

For West Africa, research with national partners will be coordinated by a group involving AGHRYMET, CORAF/WECARD and possibly AMMA, and facilitated by the Regional Facilitator working closely with the Management Team. Other organisations with a regional mandate may be added in due course. For Eastern Africa, research with national partners will similarly be coordinated by a group involving ASARECA and ICPAC, and facilitated by the Regional Facilitator, again working closely with the Management Team. Other organisations with a regional mandate may be added in due course. ACMAD will liaise closely with both West and Eastern Africa coordination groups, and further links will be explored with other regional organisations, including COMESA.

For the IGP, research with national partners will be coordinated by a group involving the Rice-Wheat Consortium (which will bring links to agricultural research institutions in each country) and a leading climate change institute from each country.

Close liaison with the WFP, FAO and other major international organisations will build links with policy processes at the highest levels both regionally (e.g. with the AU in Africa) and nationally.

4.7. Incorporating gender into the research portfolio

Recognising that the CCAFS goal is to achieve food security and enhance livelihoods, and recognising that achieving this goal needs to take into account the different assets, vulnerabilities, and priorities of men and women, CCAFS will mainstream gender into its research portfolio. Each MTP Project has Output Targets and deliverables that deal with gender issues and/or each MTP Output incorporates gender-responsive processes (e.g. ensuring consultation processes are inclusive). Gender-related work in CCAFS will be tracked in order to facilitate monitoring and evaluation.

4.8. Capacity building

Capacity building in both science and policy will be an integral aspect of CCAFS and will cut across all Projects and regional activities. It will encompass S–N, N–S and S–S aspects. Some CCAFS-wide activities, for instance scenario development (Project 1, Output 1), offer a powerful capacity-building framework, and in themselves culminate in the establishment of multi-disciplinary science/policy teams who have grown to trust either other and form an effective long-term resource. Capacity building

will recognise that CCAFS must not only focus on current science and policy decision-makers, but must also seek to build the capacity of the next generation who will be responsible for action at a time when climate change and its impacts are probably going to be much more evident. In this respect, universities in the South will be important partners, and CCAFS will seek to ensure that advanced climate science is built more strongly into their curricula. In principle, capacity building will be achieved in a number of ways.

Science capacity will be built by:

- Networking scientists across the region and across disciplines to jointly address common research issues.
- Inception workshops run by Theme Leaders and other resource people to bring regional researchers up to date on latest concepts and methods.
- Linking regional researchers with scientists world-wide through the wider CCAFS research agenda, and especially the inter-regional synthesis activities.
- Regional training and dissemination workshops, particularly for NARS affiliated with SROs and for national meteorological services associated with regional climate centres in the focus regions.
- Meetings with regional policy-makers so that the science community is more aware of the key issues facing policy-makers and the constraints under which they have to work.

Policy capacity will be enhanced by:

- Involving regional policy-makers in scenario exercises to raise their awareness of climate change issues and the consequences of given scenarios for development.
- Working with policy-makers to interpret research findings in the context of policy formulation.
- Providing decision support tools to help with analysing trade-offs between socioeconomic and environmental goals for given adaptation options.

A specific outreach and capacity-building training effort will be targeted at young agricultural scientists and policy experts, to ensure adoption to the highest degree of the data and analysis capabilities developed under CCAFS. An accreditation programme is envisioned to provide standardisation and tracking of policy implementation. This will be linked to the UNFCCC Nairobi Work Plan. This could be developed via links through ESSP-START (the ESSP SysTEM for Analysis, Research and Training), thereby building on programmes such as Assessments of Impacts and Adaptation to Climate Change (AIACC) and Advancing Capacity to Support Climate Change Adaptation (ACCCA).

5. Financial highlights

The CCAFS budget for 2010 is US\$10.5 million. The projections for 2011 and 2012 are US\$17.6 million and US\$20.8 million, respectively. The Medium Term Plan is based on confirmed grants and on-going discussions with funding agencies. A balanced budget for 2010 is projected.

Personnel costs will be less than 15% of total costs in the MTP period. Partnership activities will be around 80% of costs, in line with the CCAFS strategy of working through partners.

The University of Copenhagen provides CCAFS with facilities and infrastructure at no cost and many of the basic services come without an overhead charge to CCAFS.

5.1. Financial health indicators

The CCAFS Steering Committee will discuss and agree key financial health indicators at its first meeting in 2010, and these will be set out in MTP 2011–2013.

5.2. Risk management

The CCAFS Steering Committee will discuss and agree on a risk management framework (based on that of the CGIAR Internal Audit Unit) at its first meeting in 2010, and this will be set out in MTP 2011–2013.

6. Project narratives

6.1. Project 1: Diagnosing vulnerability and analysing opportunities

Project overview and rationale

Identifying viable technological and policy options to improve food security in the face of climate and other environmental changes requires improved dialogue between researchers, policy-makers and resource managers. Better dialogue is particularly important at the regional level where many regional policy options arise. Project 1 will develop a coherent set of regional scenarios that examine potential development scenarios under a changing climate and differing pathways of economic development. Prototype scenarios will be produced in 2010 and discussed at the CCAFS Launch Conference, while fully quantified scenarios, based on data from across numerous MTP Projects will be produced in 2012.

Much of the work of CCAFS will require temperature and precipitation scenarios downscaled from general circulation models (GCMs) and regional climate models (RCMs). For instance, to identify adaptation pathways that are robust across the range of possible realisations of climate change, the research will need to incorporate probabilistic, downscaled climate projections. Similarly, anticipating climate-driven spatial shifts will require integrated downscaled climate projections with analysis of agro-ecological zones. Project 1 will identify regional climate trends and variability, and assess methods for downscaling climate change information for agriculture and natural resources management.

There is a considerable body of work on the likely impacts of increasing CO₂ levels, increasing temperatures, and shifting rainfall amounts and patterns on crops, pests, ecosystems and natural resources (MA, 2005; UNEP (GEO4), 2007; CA, 2007; IPCC, 2007). While some work has also been done on likely impacts on the agricultural, water and forestry sectors explicitly (e.g. Bruinsma, 2003; IAASTD, 2007), the level of aggregation in such studies is high and the level of detail low. There is thus a need for methods, analytical frameworks, models, databases, and system metrics to enable us to assess the likely impacts of climate change and climate variability on agricultural and food systems, particularly in the context of other social and economic change. These same tools can be used to help

guide decisions in CCAFS – and outside it – concerning the allocation of research resources, the specific research topics, and where to execute these in order to optimise the efficacy of the CCAFS activities. We also need methods and tools to assess the likely impacts of different interventions – adaptation and mitigation options – in terms of their effects on poverty alleviation, food security and the environment. What the likely impacts of different interventions will be is a critical input into identifying the trade-offs and thus best-bet options for specific climate challenges.

Goal and objectives

The goal of Project 1 is to help target adaptation and mitigation strategies to vulnerable populations. It will provide information on alternative strategies and scenarios that can be used by agencies developing such strategies. It can thus, for example, guide the investments of the global Adaptation Fund, while also being relevant to national actors developing adaptation strategies. It will also provide a system for priority setting for future research on climate change adaptation and mitigation.

The Project will produce regional scenarios of development under climate change; analyse climate variability and change at scales relevant to such regional scenarios and at scales relevant to farmer decision-making; design and implement an analytical framework for diagnosing the vulnerability of agriculture and food security to climate variability and climate change; and analyse the opportunities for adaptation and mitigation together with their trade-offs on poverty, food security and the environment.

The objectives of the Project are:

- to establish a coherent set of regional scenarios that examines potential development scenarios under a changing climate and differing pathways of economic development;
- to identify regional climate trends and variability;
- to assess methods for downscaling climate change information for agriculture and natural resources management;
- to establish an integrated assessment framework and toolkit to enhance capability to assess climate change impacts on agricultural systems and their supporting natural resources; and
- to analyse the likely effects of specific adaptation and mitigation options.

6.1.1. Project 1, Output 1: Establishment, through scenario analysis, of a coherent set of scenarios that examines potential development scenarios under a changing climate and differing pathways of economic development

Output description

Scenario analysis is a powerful tool to engage stakeholders, and to develop joint visions of the future to guide research investments and the development

interventions of implementing agencies and policy-makers. Scenario exercises will build relationships with a variety of stakeholders with divergent and varied perspectives, and provide a robust yet flexible process for planning under uncertainty over time and in the context of change. In keeping with mainstreaming gender into CCAFS, special attention will be paid to ensuring gender parity in the process of building these relationships.

Scenario analysis will be undertaken to assess the possible trajectories of agricultural and food systems in the case-study regions and the likely impacts of different pathways on food security, livelihoods and the supporting natural environment. Key tipping points in system productivity and vulnerability will be identified, so that opportunities for dealing with them may be defined and assessed. Links will also be made to formalise results in the context of the Geospatial Diagnostic Toolkit GEDIT system (see Project 1, Output 3).

Scenario analyses conducted at regional level will help systematically explore options at the appropriate scale by providing a suitable framework for (i) raising awareness of key environmental and policy concerns, (ii) discussing viable adaptation options, and (iii) analysing the possible consequences of different adoption options for food security and environmental goals. These can be based on scenarios developed at the global scale (e.g. Millennium Ecosystems Assessment, UNEP-GEO; MA, 2005). Such analyses do not necessarily feature issues that are particularly relevant at a regional level. Further, they do not necessarily address all the issues related to agriculture and food security. CCAFS will lead the development of a set of integrated scenarios for each region. The scenario analyses will bring together the outcomes of the CCAFS Projects to deliver policy-relevant outputs specifically tailored for regional conditions and issues. The development of scenarios is an important part of communications and capacity building and will help build regional science-policy teams who can take forward CCAFS outputs.

Scenarios will be developed for each region based on existing work; for example, the MA (2005) outlines four developmental pathways characterised by specific population growth rates and levels of economic development (among other things), and IPCC (2007) outlines corresponding emission scenarios of GHGs, and levels of human appropriation of natural resources and ecosystem services. These scenarios can be quantified using a broad suite of existing models that project land-use changes, changes in food and feed demand, changes in water use, and changes in agricultural production. Scenario analysis should allow for characterisation of development pathways in the study regions.

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 4D *Sustainable agro-ecological intensification in low- and high-potential areas*, and its specific goal: *To improve understanding of degradation thresholds and irreversibility, and the conditions*

necessary for success in low productivity areas. Similar work will also be conducted for high potential areas.

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- Scientific understanding of development scenarios under changing climate and differing pathways of economic development.
- Insights into which adaptation and mitigation strategies might be conceivable and viable to best strengthen regional food security under various scenarios.
- Knowledge drawn from three regional scenario analysis processes that establishes best practice in scenario development.

Impact pathways

This Output aims to inform and influence national, regional and global policy processes and institutional agendas, and to ensure that the key actors have access to the best available science-based knowledge on adaptation and mitigation options under a range of scenarios. The IPGs will be tailored for such policy audiences.

This Output will provide information on alternative strategies and scenarios that can be used by agencies to develop adaptation and mitigation strategies. It will engage key actors to ensure that climate variability and climate change issues are appropriately mainstreamed into national, regional and international agricultural development strategies and institutional agendas.

The new information in the IPGs provided by this Output can be used at various levels. At the global level, key intended users are the global Adaptation Fund, UNREDD, the World Bank, key bilateral donors developing adaptation and mitigation strategies, and large international NGOs entering this arena (e.g. CARE International). A similar suite of players are relevant at regional and national levels (e.g. for Eastern Africa COMESA is rolling out climate change policies). This Output will help these players set priorities to identify and fund adaptation and mitigation policies and investments. Changes in development strategies and institutional agendas of these global, regional and national players will in turn affect target populations.

At the global and regional level, the main impact pathways of CCAFS will be through direct and indirect engagement with global and regional climate policy processes, including the UNFCCC/SBSTA at the global level, and by influencing key global and regional actors.

While some of the intended users will be engaged directly in the research itself, and in particular in the scenario development process, others will be specifically targeted through dissemination efforts and targeted engagement. For instance major side events are planned at a number of SBSTA and COP events of the UNFCCC.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in the Project. Theme Leaders, Regional Facilitators, and research partners will be identified in the latter part of 2009.

6.1.2. Project 1, Output 2: Identification of climate trends and variability, and assessment of methods for downscaling climate change information for agriculture and natural resources management

Output description

Climate models are the only practicable means of predicting future global climate. Models used in IPCC AR4 exhibit strikingly different levels of skill in simulating current climate and inconsistencies concerning projected future climate, particularly the amount of rainfall, the large-scale patterns of climate that cause variability and the more detailed simulation of variables such as cloud and diurnal temperature to which crop yield is highly sensitive. The fidelity of climate models on these counts is highly region-specific. Limited work has been done to date on assessing the ability of different climate models and downscaling methods (both numerical and empirical), within the context of agriculture, to reproduce observed present-day climate patterns in response to historical forcing experiments in the study regions. The studies that have been done are inadequate for assessing future agricultural vulnerability. This needs to be addressed. In addition, work is being done on coupling weighted ensembles of regional climate simulations to crop models in an effort to estimate potential impact on future yields of important crops (e.g. Lobell and Field, 2007). Extending these methods, while tailoring regional focus and methodology to the needs of the CCAFS, should prove a fruitful pathway for developing information suitable for agricultural application.

A particular problem and crucial information gap lies between seasonal prediction (<12 months) and forthcoming decades when the GHG forcing is sufficiently strong to exceed internal variability (2020s and beyond). This gap corresponds with time periods for which there is great user demand for information. Novel methods need to be developed to deal with this hiatus. For example, information regarding regional natural variability as it has existed in the past is being developed, and can be used to characterise uncertainty ranges in climate projections going forward. This is one way in which decision-makers may be able to take account of this component of climate variability.

This Output will assess the methods for downscaling climate change information and will assess the climate change information needs of the agricultural and natural resource management community. The Output will also analyse what changes in climate and climate variability are anticipated in the selected study regions and in other candidate study regions in the coming decades that will have a direct bearing on food production systems, natural resources and rural livelihoods. In the first instance, the knowledge generated by this Output will be used in the

scenario analyses, but similar climate information is needed for Projects 2, 4, 5 and 6.

Alignment to CGIAR System Priorities

This Output is essential input into numerous CGIAR System Priorities, but in CCAFS is mainly directed at SP 4D *Sustainable agro-ecological intensification in low- and high-potential areas*, and its specific goal: *To improve understanding of degradation thresholds and irreversibility, and the conditions necessary for success in low productivity areas*.

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- to Scientific understanding of downscaled climate trends and variability relevant to agricultural development and natural resource management in developing countries.
- to Knowledge on how to best enable stakeholders to access and use relevant downscaled climate information products and knowledge to improve food security, livelihoods and management of the natural resource base in the face of a variable and changing climate.

Impact pathways

The impact sought by this Output is reduced vulnerability to climate change by poor rural dwellers.

Information on likely climate change trends in developing countries is essential to forward planning for climate change adaptation strategies and for targeting agricultural research to future climatic conditions. Knowledge generated through the IPGs in this Output will allow meteorological agencies and climate modellers to better understand the information needs of their clients and to better generate downscaled climate data for specific regions and timescales. Better downscaled data on climate trends and variability will help agricultural and natural resource planning agencies to develop adaptation strategies relevant to future climates.

Key intended users of this Output will be national meteorological services, the African Centre of Meteorological Applications for Development (ACMAD) and the regional organisations it services (e.g. CILSS), agricultural research agencies (including CGIAR and NARS), and agencies planning adaptation strategies (e.g. bilateral funding agencies, government, large international NGOs).

CCAFS will engage the partners directly through stakeholder meetings and workshops, and by participating in regional processes facilitated by the key agencies. New ways of approaching climate change information will be communicated at carefully selected international events to promote uptake. The IPGs can be directly used for promoting change along the impact pathway, and will be prepared in various formats for different kinds of users.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators, and research partners will be identified in the latter part of 2009. Partners such as ACMAD will be crucial to the research and impact strategy.

6.1.3. Project 1, Output 3: Integrated assessment framework and toolkit to enhance capability to assess climate change impacts on agricultural systems and their supporting natural resources, and analysis of likely effects of specific adaptation and mitigation options

Output description

The IPCC AR4 presents the most authoritative voice on climate change, but is a review of available published research rather than a dedicated and commissioned effort to unravel specific sector impacts, such as on agriculture. Given the heterogeneity of climate change impacts at different spatial levels, a serious knowledge gap exists. In addition, relatively little is known about the interactions of climate and increasing climate variability with other drivers of change in agricultural systems, and on broader development trends. *Perhaps most importantly, we do not currently possess a framework to analyse the implications (both positive and negative) of human responses to the climate challenge in terms of regional food security and the preservation of important ecosystem services, upon which the long-term sustainability of global agriculture must be based.* Such interactions may themselves be strong determinants of vulnerability to climate change. While the broad trends may be discernible, much more detail is required concerning localised impacts of climate change, effects on livelihood systems, and options that can increase the well-being of people dependent on natural resources for their living.

The tools needed for the tasks of assessing the impacts of climate change on systems, and of assessing the impacts of interventions on the same systems are essentially the same: a comprehensive and quantitative framework that both interrogates and pulls together what is known about the climate system, the ways it may change into the future, the associated impacts on agro-ecosystems, the livelihoods of those who depend on them, food security, and feedbacks to the Earth system. While much is known about many components, no integrated framework yet exists. There are key gaps and uncertainties in knowledge concerning some processes, in model capacity and in high-resolution databases. The work proposed under this Output (and many other Outputs) is designed to address these gaps, many of which the CGIAR and the ESSP are uniquely placed to fill. We also propose to use the integrated framework that is developed here to help set in place systems for monitoring and evaluating CCAFS research activities. Towards the end of CCAFS, the framework will also be used for *ex-post* assessment of the research work, its outputs, and its outcomes, in relation to a 'baseline' set of key indicators that will be measured at the start in the regional case study sites.

Drawing from the wide range of candidate models (climate, biophysical, integrated), analytical methods, and databases to be used in CCAFS, critical gaps need to be assessed and acted upon. Procedures to fill these gaps need to be implemented for evaluation in the study regions, with both researchers and different stakeholders working in tandem.

This Output will address the following questions:

- What are the specific impacts of climate variability and climate change on agricultural and food systems and the people who depend on them directly for their livelihoods, both now and into the future? (*i.e. how is the system vulnerable?*)
- Where are (a) the impacts of climate variability already large, (b) climate change impacts in the future likely to continue to be large or to emerge as important challenges, and (c) adaptation and mitigation options likely to have large effects on poverty alleviation, food security and environmental sustainability? (*i.e. where and how can we intervene appropriately now?*)
- How will agriculturally-based livelihood systems evolve in the coming decades, specifically in the light of climate change, but also in the light of population growth, globalisation of markets, and development investment policy? What will be the resultant vulnerabilities and opportunities? And how could response strategies fit into this changing set of biophysical challenges? (*i.e. how will things change in the future, and how can we prepare?*)

- How will climate change affect bio-geochemical cycling in the selected study regions, in systems that are nitrogen (highland) or phosphorus (lowland) limited?

CCAFS will integrate the increasing body of literature exploring the explicit links between climate change, agriculture, food security and natural resources (e.g. Bruinsma, 2003; Ericksen, 2008; Gregory and Ingram, 2008; Ingram et al., 2008) within a framework based on the archetype approach (Lüdeke et al., 2004; Eisenack et al., 2007) to better investigate the links between climate change, food security, and resulting societal consequences. This will bring together latest conceptual advances with empirical knowledge from the field, with the aim of identifying a small number of key cause-effect relationships. These would then be modelled using innovative techniques that integrate knowledge from different sources and of different types. The resultant model will be used to diagnose different situations where specific hazardous developments are being manifested, and to assess the possible impacts of specific interventions and management options. A wide variety of information sources will be used to implement the approach, including point and spatial data, existing case-study syntheses, and expert assessment.

An indicative data integration and modelling framework (Figure 4) draws these various elements together and provides an integrated package of approaches that will be used to

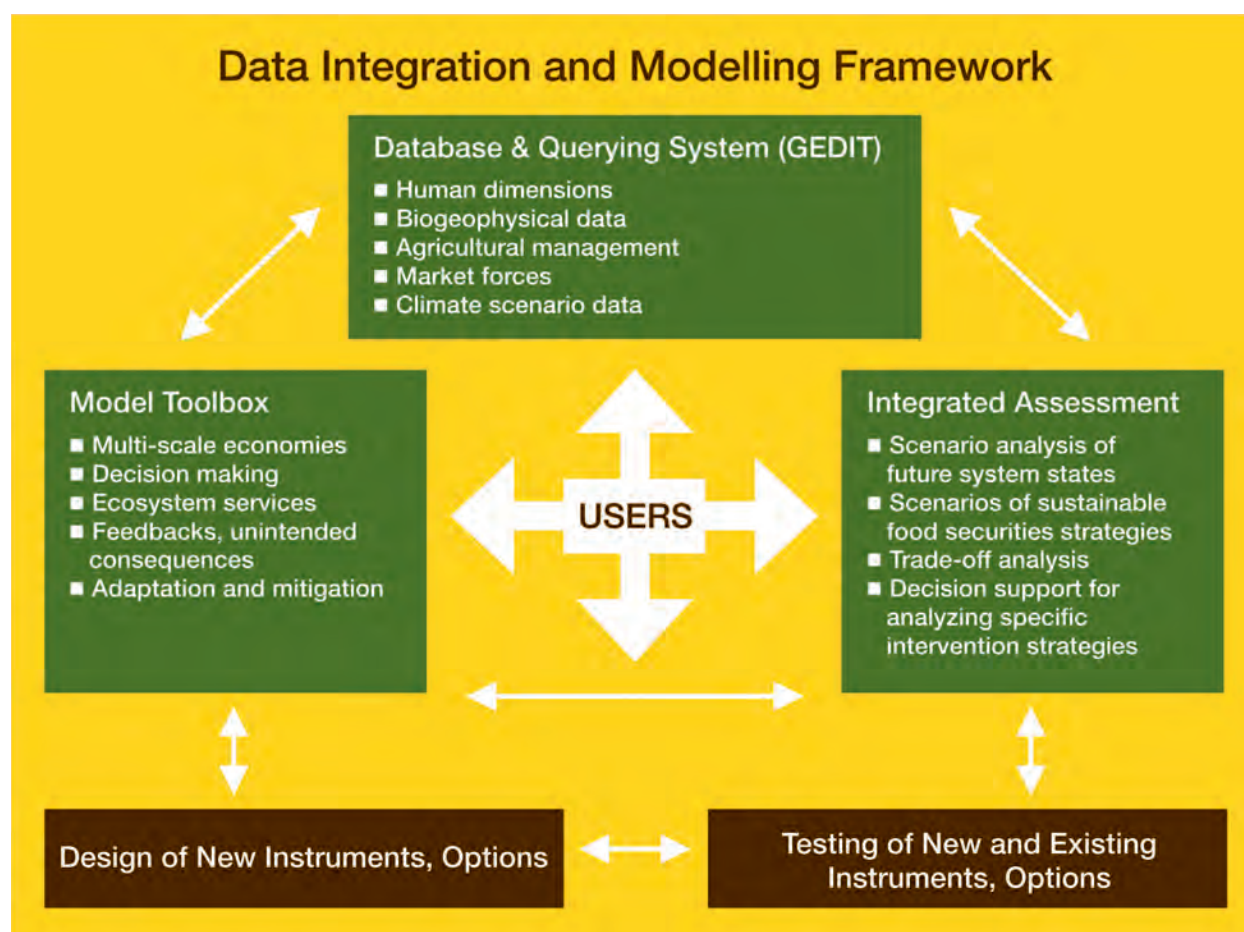


Figure 4. CCAFS data and integration modelling framework.

assess a wide variety of adaptation and mitigation options and policy instruments under a range of climatic and socioeconomic futures. Detailed databases coupled with a querying system (GEDIT, see below) will be linked to suites of models that describe the economic and biophysical dynamics of agricultural production in relation to the climate system, and that are able to incorporate Earth system dynamics to assess the feedbacks of specific economic and biophysical strategies on major system variables, such as land use, soil carbon and fertility, water supply and pollution, trace gas emission and biodiversity. The model toolbox will be created drawing on the modelling work proposed in several Projects (2, 5 and 6). This Output will provide the conceptual framework and ensure the integration of different modelling components. It will also focus on the database and querying system and provide the integrated assessment component.

This Output will see the development and application of GEDIT (the GEospatial Diagnostic Toolkit). Diagnosis of the vulnerability of agricultural and food systems in response to climate variability and change needs to be based on robust, quantifiable metrics that can be tracked. GEDIT will be established for each study region to identify hot-spots of change, monitor CCAFS progress through time, assess the efficacy of policy and technology interventions, and allow multi-site comparisons and extrapolation. In addition to yielding important insights into the capacity of food production systems to assure food security in the light of ongoing climate and other changes, GEDIT will also permit broad access to decision-making tools of value to local stakeholders as well as to macro-scale policy-makers. Arming the next generation of agricultural researchers and the public with state-of-the-art agronomic and environmental system information sets will result in important spin-off benefits in areas of the world where these may be the only practicable sources of quantitative information upon which to design interventions.

GEDIT will involve the development of spatially refined indicators of food production systems that can be mapped and their potential sensitivities to climate variables. Its design will take advantage of new open-source GIS protocols and web-based data distribution capabilities. It will encompass a broad suite of spatial and statistical data encompassing point-scale and gridded socioeconomic and bio-geophysical datasets that users will be able to explore and manipulate in various ways. Examples of data themes to be included are crop and livestock distributions, human population, poverty rates, land use and land cover, infrastructure, climate and ecosystem services inventory. These datasets, which will need to be constantly replenished and updated, will be organised according to food security themes and presented in the spatial context of a variety of organisational frames. This flexibility will accommodate contrasting elements such as administrative unit, agro-ecological zone, and river basin, and reflect different management units, for example the provincial government, river basin, agro-ecological zone, etc. Under any unit structure, the system will be used to analyse the changing nature of food security in relation to human needs and activities over local-to-regional and case-study scales.

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 4D *Sustainable agro-ecological intensification in low- and high-potential areas*, and its specific goal: *To improve understanding of degradation thresholds and irreversibility, and the conditions necessary for success in low productivity areas*. Similar work will also be conducted for high potential areas.

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- An enhanced analytical framework, suite of tools and infrastructure to enable stakeholders to diagnose vulnerability; and to better target and assess likely impacts of adaptation, mitigation and policy interventions.
- Large climate and other primary datasets. Online collaboration systems will create a transparent and participatory environment for the efficient and effective production, integration and inter-operation of the dataset resulting from CCAFS.
- A repository of information on vulnerable populations and probabilistic projections of climate impacts under a set of development scenarios.
- New knowledge on the likely effects of specific adaptation and mitigation options in three target regions.

Impact pathways

Key intended users of the datasets will be the numerous agencies involved in planning for and researching climate change impacts on agriculture and natural resource management. CCAFS will target these users by engaging the dozen or so key agencies that drive the agenda on climate change information provision, and by disseminating the results of the IPGs in appropriate formats.

This Output will provide a system for priority setting for future research on climate change adaptation and mitigation. Key intended users will be those funding and undertaking agricultural research (e.g. CGIAR, NARS). More effective priority setting and research resource allocation is essential in the face of climate change. Better priority setting and allocation will arise from a more complete understanding of the impacts of climate change on agricultural and food systems.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators, and research partners will be identified in the latter part of 2009.

The GEDIT approach will be built around partnerships among users and providers of these data sets (including the wider CGIAR and ESSP communities), and CCAFS will catalyse the requisite workshops and other professional

interactions. Help will be sought from existing data centres (e.g. the World Data Center for Climate, the IRI for climate and environmental data; Center for International Earth Science Information Network, (CIESIN) for agricultural, environmental and socioeconomic data; CGIAR Consortium for Spatial Information; Alliance Center or ARI lab for establishing and hosting the data management centre of CCAFS). Collaboration with the Group on Earth Observations of the Global Earth Observation System of Systems (GEOSS) will be sought.

6.2. Project 2: Unlocking the potential of macro-level policies

Project overview and rationale

Climate variability and global climate change impacts and options for mitigation and adaptation are deeply embedded within both a highly dynamic policy environment (Stern 2006; IPCC, 2007) and a complex Earth system (Kabat et al., 2004; Lüdeke et al., 2004). Appropriate macro-level climate change policies and institutions can stimulate pro-poor investment, increasing the profitability of environmentally sustainable practices to generate income for small producers, and create investment flows for rural communities. For example, post-Kyoto carbon regimes could help finance developing-country climate adaptation and mitigation strategies, while at the same time supporting agricultural and rural development (FAO, 2007). This will require appropriate incentive mechanisms to create a 'balanced portfolio' of development strategies that foster adaptation and take advantage of the mitigation benefits of intact ecosystems (Kindermann et al., 2006). At the same time macro-level trade, development or other policies can alter vulnerabilities to climate stresses and influence the potential of mitigation efforts at more local levels (O'Brien and Leichenko, 2000).

Critical issues under this Project include understanding the interrelationships among macro-level policies, poverty alleviation, agriculture, climate change outcomes, and unintended consequences on the environment; and how these policies can be directed towards both improved coping and adaptation and mitigation strategies for the rural poor under climate change while enhancing environmental sustainability. Special attention will be paid to the likely impacts of policies on the most marginalised populations, including the poorest of the poor, indigenous people, women and children.

In addition, this Project will deliver the tools and methods to build this understanding. Investigating the effects of alternative macro-economic policies and institutions on climate adaptation and mitigation strategies under a range of climate and socioeconomic futures will require an integrated package of approaches, involving detailed databases, models uniting climate, economic, bio-geophysical and agricultural production systems, and a

global general equilibrium model.

Goal and objectives

The goal of Project 2 is to help identify macro-level policies that provide opportunities for adaptation and mitigation strategies. The Project focuses on identifying the opportunities as well as constraints inherent in macro-level policies. It investigates unlocking their potential for adaptation and mitigation to enhance developing-country agricultural growth, food security, poverty reduction and environmental sustainability through innovation in the design and execution of policy interventions.

The objectives of the Project are:

- To improve approaches and tools for assessing the impacts of macro-level policies on adaptation and mitigation strategies.
- To make recommendations for macro-level policies that provide opportunities for adaptation and mitigation strategies to reduce vulnerability and promote food security.

6.2.1. Project 2, Output 1: Improved approaches, tools and databases for assessing the impacts of macro-level policies on adaptation and mitigation strategies

Output description

This Output delivers the approaches and tools that are needed for investigating the effects of alternative macro-economic policies and institutions on climate adaptation and mitigation strategies under a range of climate and socioeconomic futures. The tools and knowledge base to assess the issues highlighted in Output 2 of this Project from the necessary integrative standpoint are currently not available and the full impacts of these macro-level strategic issues thus remain poorly understood. Assessing the effects of macro-level policies will require an integrated package of approaches, the framework for which is being developed in Project 1, Output 3 (Figure 4). Three main components will be linked: (i) a detailed database of human dimensions, crop research, natural resources, climate and other Earth system science, and econometric information sets (Project 1, Output 3); (ii) models uniting the economic and bio-geophysical dynamics of agricultural production (crop, livestock, forestry, and aquatic resources) (Project 5, Output 3), with temperature and precipitation scenarios downscaled from general circulation models (GCMs) and regional climate models (RCMs) (Project 1, Output 2); and (iii) established integrated assessment models for climate change, but incorporating Earth system dynamics to assess the 'downstream' impacts (i.e. feedbacks) of sector-specific economics and biophysical strategies in the context of major system variables (i.e. land and soil carbon and fertility, water supply and pollution, trace gas emission and biodiversity) (Project 1, Output 2). This Output will provide for the policy and much of the economic modelling components of the integrated system.

This Output will also provide the tools for analysing how macro-policies will affect outcomes of adaptation and

mitigation options on changes in regional food availability, land use, water use and agricultural growth under different scenarios. This will involve the use of a global equilibrium model that is linked with the necessary sector and environmental models.

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 5D, *Improving Research and Development Options to Reduce Rural Poverty and Vulnerability* and its specific goal: *To identify agricultural research and development pathways, in order to implement options to reduce rural poverty at global and regional levels.*

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- An integrated package of approaches to assess the impacts of macro-level policies, involving databases and models.
- A global general equilibrium model that links changes in regional agriculture and food systems to other key sectors of the economy, under various climate change and development scenarios.
- A comprehensive, searchable digital library for macro-policy issues tailored to adaptation planning.

Impact pathways

This Output will produce tools that can be used by economic think tanks, and national and regional planning agencies. The key agencies at the global and regional levels will be engaged directly in the early phases of the research so that the tools produced meet their needs and requirements. The IPGs will be tailored for the different kinds of audiences along the impact pathway. Through use of the products the impact of enhancing food security and reducing emissions in rural farming areas will be achieved.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators, and research partners will be identified in the latter part of 2009.

6.2.2. Project 2, Output 2: Recommendations for macro-level policies that provide opportunities for adaptation and mitigation strategies

Output description

A broad suite of macro-policy objectives is directly linked to sustainable development and food security, including issues as far-reaching as globalisation, implementation of climate control agreements, pursuit of development imperatives such as the Millennium Development Goals (MDGs), and adherence to the Conventions on public goods: on Desertification, Biodiversity, and Wetlands. Implementation of these objectives embodies a complex range of policy instruments. For example, international agreements to control climate change are apt to include

the internalisation of costs often thought of as externalities. While this is a laudable global commons goal, the capacity of developing countries to weigh positive and negative aspects of dealing with such internalisations as adaptation beyond 'good development' policies or alternative post-Kyoto global carbon mitigation regimes in the context of agricultural trade, subsidies, public finance, and other market policies, is a clear but unmet need.

To answer these kinds of questions for the three target regions the integrated modelling system derived in Output 1 will be used. In the analyses, it will be crucial to understand and assess potential trade-offs and feedback effects. Climate-focused policy objectives, for example, may lead to unintended and potentially contrary outcomes on rural livelihoods as well as on environmental systems that could reasonably be avoided. Thus, a lending policy aimed at helping climate-proof food production systems by developing large-scale irrigation systems may have the inadvertent result of simultaneously destroying the livelihoods downstream of artisanal or commercial fisheries by the emplacement of large reservoirs that distort natural discharge and temperature regimes, as well as sediment and nutrient flows. Macro-level policies could therefore have additive and potentially synergistic effects (both positive and negative) that could affect the global economic, climate, and environmental security, both directly and by facilitating or frustrating adaptation and mitigation pathways at the local level. Macro-level policies may also differentially impact different groups of rural people – indigenous groups, women, and the poorest of the poor.

Outputs from the integrated modelling will be incorporated into a global general equilibrium model to link regional changes in agriculture and food systems with other key sectors of the economy. Over the course of CCAFS, this research will move toward a dynamic coupling of these components to study linkages and trade-offs among agricultural markets, land use, the economy, and soil, vegetation and water, as they affect carbon balance and the major nutrient cycles, which in turn will define agricultural sustainability at the macro-scale. Quantitative analyses will be complemented with qualitative data and studies, including expert and focal group interviews involving a variety of stakeholders including marginalised groups, women, etc.

This Output will address the following key research questions:

- How do different climate policies affect developing-country agricultural growth, food security, poverty and environmental sustainability?
- How could local-level technical and policy interventions for adaptation and mitigation be fine-tuned to be more effective in the context of macro-level policies?
- How could the macro-policies that drive globalisation be adjusted to both minimise adverse environmental impacts of embodied levels of exchanged input goods (e.g. virtual water, nutrients) and services, and promote rural livelihoods?

Results of the modelling and data analysis will be synthesised with current literature to assess the effects of macro-level policies on rural livelihoods and poverty alleviation as an integral component of overall CCAFS implementation.

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 5D, *Improving Research and Development Options to Reduce Rural Poverty and Vulnerability* and its specific goal: *To identify agricultural research and development pathways, in order to implement options to reduce rural poverty at global and regional levels.*

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- New knowledge on the opportunities as well as constraints inherent in macro-level policies in an era of progressive climate change.
- Enhanced knowledge base on the effectiveness of macro-level climate change mitigation strategies and other economic, environmental and development intervention policies for supporting adaptation in agriculture and natural resource management.
- Detailed understanding of the capacity of the Earth system to provide the resources necessary under selected macro-economic policies.
- New understanding of the potential for adaptation and mitigation policies to enhance developing-country agricultural growth, food security, gender equity, poverty reduction and environmental sustainability.
- Enhanced knowledge about the impact of carbon taxes and alternative cap-and-trade regimes on developing-country agricultural and economic growth, food security, poverty and environmental sustainability

Impact pathways

The policy recommendations of this Output will be delivered through coalitions of policy partners and decision-makers, researchers, regional information networks, pro-poor civil society organisations and development donors. CCAFS will work towards including women in the policy dialogues that will be stimulated by this Output. The proposed IPGs, in appropriate formats, will be directly targeted to the intended users.

This Output will inform the ongoing negotiations of the UNFCCC and the assessment processes of the IPCC by conducting a comprehensive scenario analysis that compares macro-level mitigation and adaptation policies and investments on the basis of their overall benefits in developing country agriculture and on livelihoods of the poor. This Output will also provide direct and tangible support to the UNFCCC Nairobi Work Programme on Impacts, Vulnerability and Adaptation to Climate Change by directly focusing on its two key objectives: "(i) to assist developing countries to improve understanding and assessment of impacts vulnerability, and adaptation and (ii)

to assist all Parties to make informed decisions on practical adaptation in light of current and future climate variability and change". Through achieving these outcomes, the proposed impact of reducing vulnerability, enhancing food security and reducing emissions in rural farming areas will be facilitated.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators, and research partners will be identified in the latter part of 2009. Partners such as ACMAD will be crucial to the research and impact strategy.

6.3. Project 3: Enhancing engagement and communication for decision-making

Project overview and rationale

To respond to climate change and improve food security, multiple stakeholders must develop their capacity to anticipate and plan for changing conditions and uncertainty. This calls for a better understanding of the gaps between the knowledge stakeholders have available to them and their needs for information to make better adaptation decisions. Successful mitigation and adaptation will entail not only individual behavioural changes, but also changes in technology, institutions, agricultural systems and socioeconomic systems. These changes cannot be achieved without improving interactions between scientists and decision-makers at all levels of society – to better match supply and demand of information, to develop and share appropriate adaptation tools, and to continually assess and address the need for new resources and information (Moser and Dilling, 2007).

Vogel et al. (2007) note that the attempt to produce 'useful' science often occurs in isolation from the science-practice interface. Consequently, decision-makers and managers do not receive or use information that is produced and, despite new scientific knowledge, they may not have up-to-date information on vulnerability to environmental change. These authors point to the need to improve communication and engagement, noting that both science and practices change as the result of more interaction between researchers and stakeholders, "sometimes in unexpected or unintended ways" (Vogel et al., 2007, p. 351). The type of communication and engagement is important, and strategies may include participation, integration, social learning and negotiation. An important point emphasised by van Kerkoff and Lebel (2006, p. 445) is that "the unique contribution of research-based knowledge needs to be understood in relation to actual or potential contributions from other forms of knowledge".

Goal and objectives

The goal of Project 3 is to bring new knowledge to bear on the relationship between scientists and decision makers, at all levels, in order to facilitate the uptake of scientific information that improves outcomes for the environment and food security in the face of progressive climate change. This Project will develop and institutionalise processes for researcher–stakeholder interaction that address decision-making needs for responding to climate change. It will promote a more effective use of research for enhancing livelihoods and food security, while at the same time achieving environmental goals.

The objectives of the Project are:

- To identify key actors, their information needs and the institutional and decision-making context for uptake of policy recommendations and technical practices for adaptation and mitigation.
- To provide tools, guidelines and approaches that enhance researcher–stakeholder interaction and the uptake of scientific outputs, including from CCAFS.

6.3.1. Project 3, Output 1: Identification of key actors, their information needs and the institutional and decision-making context for uptake of policy recommendations and technical practices for adaptation and mitigation

Output description

Communication and engagement approaches must take into account the social, economic, institutional, political and cultural contexts in which both research decisions and stakeholder decisions are made, in relation to agriculture, food security and climate change (Vogel and O'Brien, 2006). These contexts influence the capacity of decision-makers to implement change, and they define the barriers and constraints to adaptation.

Actor and institutional analysis will be carried out across regions and scales, using frameworks and methods described by Bandaragoda (2000), Matsaert (2002) and Messer and Townsley (2003). Key players influencing the roll out of adaptation and mitigation strategies will be identified and engaged. In particular, this Output will identify the key impact pathways that are emerging, and undertake case studies of the decision-making process and context at different levels leading to decisions surrounding adaptation and mitigation pathways. Case studies will be selected to cover the different CCAFS Projects. Special attention will be paid to documenting the role of women in decision-making processes.

Key research questions for this Output include:

- What are the key bottlenecks limiting informed decision-making (and policy making) related to adaptation and mitigation?
- What are the gaps between stakeholders' available knowledge and their needs for information to make better adaptation decisions?
- To what extent are women part of the decision-making process, and to what extent are decisions being made

based on appropriate gender-sensitive information?

- How can communication and translation of climate and other types of information (e.g. market information) best help different groups of stakeholders identify adaptation pathways, given that exchange of information between scientists and information users is often problematic and contested?
- What are the trade-offs between research messages that translate into clear action versus more complex messages that raise a range of solutions?

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 5A, *Science and Technology Policy and Institutions* and its specific goal: *Improving the incentives for technology generation, access and use*.

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- New understanding of the role of existing policy and institutional environments on dissemination and uptake of promising adaptation strategies, and identification of opportunities for improving uptake.
- In-depth knowledge on the bottlenecks in existing research delivery systems and improved understanding of the information barriers faced by different groups of stakeholders and how research can contribute to overcoming these barriers.
- New knowledge on the decision-making (or policy) context of key issues, particularly the use of information and the role of research in supporting or contributing to decisions.

Impact pathways

CCAFS will contribute to a better understanding of the ways in which different forms of knowledge interact, in particular how and why they influence the capacity to respond to a complex issue such as climate change. The research will help farmers, communities, policy makers and many other stakeholders to cope with current climate variability and extreme events, as well as to adapt to uncertain dynamic and changing conditions in the future. At the same time, the research will help researchers to identify and understand the information needs of farmers (both women and men), as well as the social and cultural challenges of responding to climate change. This is essential for building livelihood resilience and enhancing food security in a changing world. The research will work towards empowering stakeholders as agents of change in reducing vulnerability and climate change mitigation and adaptation. It will promote a shift towards proactive adaptation rather than ongoing coping. It will promote improved operational protocols for integrating information into decision-making. Key intended users of the IPGs are researchers undertaking climate change research in the context of poverty and food insecurity. While the work will be critical to the success of CCAFS, the results will be IPGs relevant to researchers globally (at all levels: NARS,

national to global think tanks, ARIs, CGIAR). Through better understanding of the decision-making process and better targeting of information products, researchers will have more success in facilitating uptake of scientific outputs and, thus, in facilitating change.

CCAFS will engage key partners directly through case studies. New understanding of the decision-making context and information needs of stakeholders will be communicated at carefully selected regional and international events to promote uptake. The dissemination strategy will take advantage of the extensive dissemination outlets and networks that already exist, for example newsletters of the Alliance Centers and ESSP communities (e.g. IHDP Update, IGBP Global Change Newsletter, DIVERSITAS Newsletter, START, Global Water News and WCRP News).

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators and research partners will be identified in the latter part of 2009.

6.3.2. Project 3, Output 2: Tools, guidelines and approaches that enhance researcher–stakeholder interaction and the uptake of scientific outputs from CCAFS

Output description

Given the complex, dynamic and uncertain nature of climate change and its interactions with other social, economic and political processes driving agricultural development and food security, innovative methods and tools need to be developed to improve interaction between researchers and stakeholders. Different forms and models of interaction will be assessed and evaluated in relation to the particular challenges of climate change, and hybrid models will be developed. For example, research may focus on the effectiveness of participatory approaches to climate change adaptation (Roncoli, 2006); on the role of boundary organisations as an interface between researchers and stakeholders (Vogel et al., 2007); on participatory integrated assessment and social deliberation (Kemp and Martens, 2007); and on the use of integral frameworks for transmitting and translating information between researcher communities and decision-makers (Hochachka, 2004).

CCAFS research will also focus on the different values, interests and perspectives of researchers and stakeholders, and will recognise that the outcomes of adaptation will have different consequences for different stakeholders (e.g. women, men, indigenous groups, market-orientated farmers, poorest of the poor). Successful adaptations for one group of stakeholders may, for example, increase the vulnerability of other stakeholders. Furthermore, successful adaptations must be sustainable, such that they do not increase poverty and the degradation of resources, or accelerate environmental change (Eriksen and O'Brien,

2007). Ensuring that negative feedback across levels of governance and stakeholders is minimised requires an ongoing consultative process and dialogue between researchers and decision-makers (Regan, 2007).

A flexible and adaptive management process may emerge as the most successful means for addressing the complex and dynamic interactions and uncertainties related to progressive climate change, agriculture and food security. Consequently, the development of robust processes that ensure a continuing dialogue between researchers and stakeholders will be an underlying element of CCAFS. It will represent a collaborative learning process, involving not only CGIAR and ESSP researchers, but also experts with skills in facilitation and human development, knowledge brokers, and development practitioners who can help to integrate across disciplines and perspectives. These processes will ensure that CCAFS results are used effectively in national- and local-level policy and decision-making processes on adaptation. Simultaneously, they also influence the type of research that is undertaken, and the types of adaptations that are prioritised or promoted.

An example of a tool to increase interaction between stakeholders and researchers is the 'learning wheel', developed as part of the Integrated Natural Resource Management (INRM) task force of the CGIAR (Campbell et al., 2006a, b). This tool is based on principles and operational guidelines that present a new way of approaching research and development. CCAFS research will further develop and apply such approaches to account for the new challenges that climate change introduces to the management of resources. It will draw upon experiences of how farmers and communities already adapt to climate variability and extreme events, and assess the role and relevance of local knowledge and experience for adaptation to the uncertain and changing conditions of the future. It will also develop and implement new approaches to communication and exchanges between researchers and stakeholders involved in the different CCAFS Projects – approaches that take into account the diversity of cultural and cognitive frameworks for understanding climate change, including how they relate to different beliefs, values and worldviews (Orlove et al., 2004; Roncoli, 2006). An understanding of the communication and information needs of stakeholders is a minimum requirement for ensuring that CCAFS results are used by decision-makers. Stakeholders will only use information that they believe has legitimacy and is relevant to the problems facing them, as they perceive them.

The guidelines and principles developed by Campbell et al. (2006a, b) will serve as a point of departure for developing case studies of researcher–stakeholder interactions. These case studies will be carried out in regional focus areas, in collaboration with other CCAFS Projects and collaborating institutions. In addition to the literature reviews, integrated analyses and case studies, a series of workshops will be organised to evaluate the findings and their implications for efforts to address climate change and food security.

Key research questions will include:

- How do different models of researcher–stakeholder interactions (e.g. participatory, boundary organisations, integral, or learning) facilitate the development and implementation of different adaptation and mitigation strategies?
- What mechanisms best strengthen the science–policy interface and promote a more effective use of research for enhancing livelihoods and food security, while at the same time achieving environmental goals?
- How can the successful models be institutionalised in diverse local contexts, and in the face of both uncertainty and ongoing change?

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 5A, *Science and Technology Policy and Institutions* and its specific goal: *Improving the incentives for technology generation, access and use*.

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- New approaches for enhancing science-policy dialogues that account for multiple perspectives and dynamic contextual factors, for multiple levels of decision making.
- Enhanced knowledge on sustainable adaptation pathways in case studies of researcher–stakeholder interaction.
- Improved tools for integrating policy objectives and climate and environmental issues that are implemented and used.

Impact pathways

CCAFS will contribute to an improved understanding of the ways that researchers and stakeholders can interact to promote change and respond to a complex issue such as climate change. As for Project 3, Output 1, research will work towards empowering stakeholders as agents of change in relation to reducing vulnerability, and mitigating and adapting to climate change. Key intended users are researchers undertaking climate change research in the context of poverty and food insecurity. While the work will be critical to the success of CCAFS, the results will be an IPG relevant to researchers globally (at all levels: NARS, national to global think tanks, ARIs, CGIAR). It is expected that the research will lead to the adoption of new approaches to researcher–stakeholder interaction, which in turn will result in improved targeting of research and improved uptake of research results by stakeholders.

CCAFS will engage key partners directly through the case studies. New ways of approaching researcher–stakeholder interaction will be communicated at carefully selected regional and international events to promote uptake of the IPGs. A similar dissemination strategy to that proposed for Project 3, Output 1 will be used.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators and research partners will be identified in the latter part of 2009.

6.4. Project 4: Adaptation pathways based on managing current climate risk

Project overview and rationale

Long-term climate change occupies the ultimate position at the end of a continuum of time scales at which the climate varies and impacts agricultural systems and their natural resource base. Many of the projected impacts of climate change are amplifications of the substantial challenges that climate variability already imposes on these systems. This is particularly true for smallholder rain-fed farming systems in the drier (i.e. sub-humid to arid) tropics which are among the human systems most vulnerable to projected climate change (Parry et al., 2005; Easterling et al., 2007), but also for a range of natural resource-based rural livelihood systems.

The damage of uninsured climate shocks, such as droughts or floods, to health, productive assets and infrastructure can affect livelihoods long after the stress has ceased (Dercon, 2004; McPeak and Barrett, 2001). Climate variability and the conservative strategies that risk-averse decision makers employ *ex-ante* is one of several factors that contribute to the existence and persistence of poverty – sacrificing appropriate investment, intensification and adoption of innovation in climatically favourable seasons to protect against the threat of shocks (reviewed in Barrett et al., 2007; Hansen et al., 2007). Limited empirical evidence suggests that the cost of climate risk in rain-fed farming systems can be quite large, and is borne disproportionately by the relatively poor, women and marginalised groups (Rosenzweig and Binswanger, 1993; Zimmerman and Carter, 2003). Without effective intervention, projected increases in climate variability can be expected to intensify the cycle of poverty, natural resource degradation, vulnerability and dependence on external assistance.

Managing current climate risk must therefore be integral to a comprehensive strategy for adapting agriculture and food systems to a changing climate. Given pressing current development challenges and a 2015 deadline for meeting the MDG targets, management of current climate risk offers attractive win-win opportunities for developing countries to contribute to legitimate immediate priorities while reducing vulnerability to a changing climate. Project 4 tackles three components of risk management: managing crop and livelihood portfolios to buffer against climate shocks; developing index-based risk transfer products to protect and enhance livelihoods; and managing climate risk at the

broader national or regional level through the food storage, trade and distribution system.

Goal and objectives

The goal of Project 4 is to identify strategies, from household to regional level, to enhance adaptation to current climate risk. This Project brings promising innovations in climate risk management to bear on the challenge of protecting and enhancing food security and rural livelihoods in the face of a variable and changing climate.

The objectives of the Project are:

- To identify crop cultivar and rural livelihood portfolios that buffer against climate shocks and enhance livelihood resilience.
- To analyse and evaluate index-based risk transfer products to protect and enhance rural livelihoods, especially the livelihoods of marginalised groups including women.
- To identify improved modalities and approaches for managing climate risk through the food storage, trade and distribution system.

6.4.1. Project 4, Output 1: Identification of crop cultivar and rural livelihood portfolios that buffer against climate shocks and enhance livelihood resilience

Output description

This Output will identify crop cultivar and rural livelihood portfolios that enhance livelihood resilience in the face of climate variability, especially for marginalised groups, including women. Research will target two levels of risk reduction. Firstly, production risk reduction efforts will focus on mixes of cultivars that differ in their phenology, or degree or mechanism of tolerance to environmental stresses, and will combine crop model-based risk analysis, analysis of existing variety data and experimental (primarily on-farm) research. Secondly, at the farm and community scales, research on diversified livelihood strategies for reducing income and food insecurity risk will integrate bio-economic modelling and farmer participatory research. The farmer-participatory research will work to ensure gender representation. Multi-agent modelling is a promising approach for integrating the various livelihood components, particularly at the community level.

Key research questions include:

- What is the climate sensitivity of existing germplasm, production and natural resources management (NRM) technology, and what are the gaps and priorities for future technology development to mitigate and adapt to projected climate change?
- What are the options for diversification at field and farm scales to reduce food security and livelihood risk and hence reduce vulnerability to climate variability?
- From the standpoint of risk and vulnerability, what is the optimal activity portfolio in a given context?

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 2A *Maintaining and Enhancing Yields and Yield Potential of Food Staples*, and its specific goal: *Identification and development of pro-poor traits in crops*.

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- An inventory and assessment of existing germplasm, production and natural resources management (NRM) technology for climate sensitivity.
- Knowledge about the climate resilience of improved crop and livelihood diversification strategies.
- New understanding about the feasibility, effectiveness and acceptability of diversified crop cultivar and rural livelihood portfolios that buffer against climate shocks.

Impact pathways

The intermediate goal of the impact strategy is to ensure that new crop cultivar and livelihood portfolios are promoted by development and funding agencies, and by civil society groups and the private sector. The ultimate goal is that there is systematic technical and policy support for increasingly diversified farming systems and rural economies that buffer against climate shocks and enhance livelihood resilience. This should foster the impact sought of increasingly diversified farming systems and rural economies that buffer against climate shocks and enhance livelihood resilience.

Thus, key intended users of the research at the global and regional levels are the funding agencies investing in agricultural development, poverty reduction and climate change adaptation; international development NGOs; and regional agencies such as SILSS and COMESA. Key intended users at local and national level are producer associations, development NGOs, national extension agencies and private companies.

Some of the intended users will be engaged directly through the research process, while others will be reached through targeted dissemination and engagement strategies.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators, and research partners will be identified in the latter part of 2009.

6.4.2. Project 4, Output 2: Analysis and evaluation of index-based risk transfer products to protect and enhance rural livelihoods

Output description

Climate risk management (CRM) is emerging as a promising framework for ensuring that climate change is considered in addressing development issues. CRM includes systematic

use of climate information in planning and decision-making, climate-informed technologies that reduce vulnerability to climate variability, and climate-informed policy and market-based interventions that transfer risk from vulnerable rural populations, including marginalised groups and female-headed households. It requires serious attention to the policy and institutional environment in which information is used and adaptations are made. CRM aims to address the full range of variability, balancing protection against the impacts of climate-related hazards with effort to capitalise on opportunities arising from average and favourable climatic seasons.

Where they are skilful, seasonal climate predictions appear to offer substantial potential to improve risk management, but seldom reach poor smallholder farmers in a useable form as part of a comprehensive package of information and support (Vogel and O'Brien, 2006; Hansen et al., 2006; Patt et al., 2007; Hansen et al., 2007). Better use of historic and monitored climate data, combined with agricultural simulation models, permits the *ex-ante* quantification of climate-induced risk needed to target innovations that have a high probability of success.

This Output addresses promising innovations in climate risk management that complement ongoing CGIAR work on climate-resilient production technology and market interventions, but that have not yet been fully exploited. Index-based insurance and other financial risk transfer innovations are promising. They overcome long-standing implementation obstacles associated with asymmetric information, and show promise for addressing risk-related constraints to rural poverty reduction and food security. Index-based insurance and related financial risk transfer products are therefore experiencing a rapid resurgence of interest as a climate risk management and poverty reduction tool, but still face important knowledge gaps (Skees et al., 2005; Barrett et al., 2007). Special attention needs to be paid to ensuring that such innovations address the special needs of marginalised groups, including women. The research will also address the policy conditions conducive to the uptake of risk transfer products. Policies that provide incentives and an enabling environment for pro-poor rural financial risk transfer services can reduce the need to sell off productive assets in the event of a climate shock and overcome the reluctance of lenders to extend credit to farmers to purchase inputs.

Research will address targeting, contract and package design, and challenges associated with implementation at scale. It will also assess management of basis risk, and the implications of seasonal forecasts and climate change projections. Methods, including empirical climate analysis, theoretical and numerical economic modelling, surveys and experimental economics, will be employed within a range of implementation pilot projects.

As implied, such innovations have to go hand-in-hand with better seasonal climate forecasting and improved climate information tailored to the needs of such innovations. This

Output will assess the use and impacts of seasonal climate prediction. Evaluation will integrate survey work, experimental economics, on-farm experimentation and monitoring, and bio-economic modelling of management responses to information. The work will also assess historic and monitored climate information, value-added climate information products (e.g. soil–water balance, crop yield, disease and pest risk) and alternative delivery mechanisms. Participatory research will develop, assess and refine information products for risk management, communication protocols and training curricula for agricultural extension and other intermediaries.

Key research questions include:

- What are the most effective design and delivery mechanisms for rural climate information products and services that support risk management at a local scale; and what new institutional arrangements and policy interventions are needed to put these in place?
- How can innovative financial risk transfer products (e.g. index-based insurance, derivatives, insured credit) be best targeted and implemented to reduce vulnerability to climate shocks and to alleviate climate risk-related constraints to improved rural livelihoods?
- How and under what circumstances can seasonal climate prediction be successfully employed to help farmers to adopt innovation during climatically favourable seasons; to protect productive assets through more effective proactive coping strategies in adverse seasons; and to capitalise on market opportunities linked to climate variations?

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 5D, *Improving Research and Development Options to Reduce Rural Poverty and Vulnerability* and its specific goal: *To identify agricultural research and development pathways, in order to implement options to reduce rural poverty at global and regional levels.*

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- New understanding on targeting, implementation and impacts of financial risk transfer products.
- Synthesised knowledge of how to most effectively target and upscale index-based risk transfer products to protect and enhance rural livelihoods, including those of marginalised groups, female-headed households etc.
- Enhanced knowledge on the most effective design and delivery mechanisms for rural climate information products and services that support risk management at a local scale; and what new institutional arrangements and policy interventions are needed to put these mechanisms in place.

Impact pathways

The intermediate goal of the impact pathway is that new risk transfer products are promoted by development and funding agencies, and by civil society groups and the

private sector. The ultimate goal is that climate risk management is incorporated into regional agricultural development strategies and agendas of NARS and other relevant institutions and that there is enhanced participation of financial market institutions in pro-poor, adaptive, climate-informed services in target regions.

Thus, the intended users are the financial institutions potentially providing such products; global, regional and national agencies that can promote such products (e.g. World Bank, COMESA, SILSS, national extension agencies); and civil society actors promoting poverty alleviation initiatives where risk transfer products can form part of that strategy. The intended users are also agencies dealing with climate risk management (e.g. regional climate centres, national meteorological services, universities, government extension agencies, regional development agencies).

Some of the users will be engaged in the research process; others will be engaged in the targeted dissemination strategy.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators, and research partners will be identified in the latter part of 2009. Partners such as ACMAD will be crucial to the research and impact strategy for climate risk management.

6.4.3. Project 4, Output 3: Identification of improved modalities and approaches for managing climate risk through the food storage, trade and distribution system

Output description

There is substantial scope for using climate information to better manage grain storage, trade and distribution (e.g. Arndt and Bacou, 2002; Hill et al., 2004), and better target external assistance within emerging food crises (Haile, 2005). Research will include scenario analysis within an economic equilibrium framework to estimate market response and welfare distribution, incorporating spatial effects associated with transportation costs and barriers to trade (the tools for this work will have been produced by Project 2, Output 1). Existing climate-informed food security early warning tools will be assessed and enhanced to inform food system management. Modelling will be integrated and ground-truthed with stakeholder participation and survey-based institutional analysis within the food system.

This Output will address the following questions:

- What are the options for managing climate impacts on food security and livelihoods at a regional scale through climate-informed strategic grain reserves, and responses to trade, distribution and food crises; and how are they best implemented and evaluated?
- What are the options for diversification at regional levels

to reduce food security and livelihood risk and hence reduce vulnerability to climate variability?

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 5D, *Improving Research and Development Options to Reduce Rural Poverty and Vulnerability* and its specific goal: *To identify agricultural research and development pathways, in order to implement options to reduce rural poverty at global and regional levels.*

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- New knowledge and a prioritised strategy for managing climate risk through the food storage, trade and distribution system.
- Enhanced understanding of the role of, and mechanisms for, early warning systems for managing climate risk through the food storage, trade and distribution system.

Impact pathways

The impact pathway will ensure that new food storage, trade and distribution systems are promoted by development, trade and funding agencies, and by civil society groups and the private sector. The ultimate goal is twofold: (a) to ensure that there is enhanced, climate-informed management of food storage, trade and delivery for food and livelihood security in target regions; and (b) to ensure the establishment of platforms for high-level coordination of climate information services, agricultural development, and disaster (e.g. food crisis) early warning and response organisations.

The key intended users of the research are funding agencies investing in agricultural trade issues and infrastructure; agencies dealing with international, regional and national trade treaties and agreements; agencies operating early warning systems; agencies involved in food crisis responses; international development NGOs; regional development agencies (e.g. SILSS, COMESA); private sector players investing in trade and marketing systems; and civil society organisations dealing with trade issues.

Some of the users will be engaged in the research process; others will be engaged in the targeted dissemination strategy.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators, and research partners will be identified in the latter part of 2009.

6.5. Project 5: Adaptation pathways under progressive climate change

Project overview and rationale

Future farming and food systems will have to be better adapted to a range of abiotic and biotic stresses to cope with the direct and indirect consequences of a progressively changing climate, for example higher temperatures, altered precipitation patterns or rising sea levels. Germplasm improvement, improved crop, livestock, aquaculture and natural resource management, and enhanced agro-biodiversity have a proven track record of decreasing susceptibility to individual stresses, and will offer increasingly important solutions for adapting to progressive climate change (Jackson et al., 2007). However, technical innovations will not be sufficient on their own. Strengthening the adaptive capacities of farmers (both men and women) and other land users requires a variety of strategies ranging from diversification of production systems to improved institutional settings. Adaptive management to continually refine these strategies will be required, and can be supported by the predictive capacity of downscaled global climate models, for example forecasts on precipitation, coupled with more effective communication with end users.

It is crucial to add value to ongoing and planned CGIAR investment in agronomic solutions in crop management and germplasm improvements by integrating them at landscape level with adaptation options in the policy domain. Project 5 will develop and test the holistic management options that farmers and other resource users will require. In terms of natural resource management, conservation agriculture offers resource-poor farmers, including female-headed households, a set of possible options to cope and adapt to climate change (Thomas et al., 2007). Improved water management will represent the key adaptation strategy in both irrigated and dryland agriculture. Emphasis will also be given to crop production systems located in the delta regions, for example IGP mega-deltas, to sustain high production potentials under sea level rise (Wassmann and Dobermann, 2007).

Intensively managed cropping systems offer a variety of entry points to adjust to projected climate change (Aggarwal and Mall, 2002; Easterling et al., 2003; Butt et al., 2005; Travasso et al., 2006; Challinor et al., 2007; Howden et al., 2007). Breeding and marker-assisted selection are important mechanisms for achieving yield improvements for most crops when suitable mega-varieties are available for introgressing improved genes (Bennett, 2003).

Adaptation for livestock production includes a variety of management options ranging from adjusting stocking rates to providing supplementary feeds (Adger et al., 2003; Howden et al., 2007). For pastoralists, however, adaptation options are very limited and mobility remains an

important strategy to cope with current climate variability. This will remain an important feature in the future (Oba, 2001), although mobility in many places may suffer because of external pressures such as population increase and changes in land tenure. Aquaculture is an important food source in many developing countries and may become even more important as a means of improving food security in response to progressive climate change (Allison et al., 2007).

Several adaptation strategies have been suggested for managed forests, but in large areas of forests in developing countries there is minimal direct human management, which limits adaptation opportunities (FAO, 2000). Even in more intensively managed forests, where adaptation activities may be more feasible, the long time-lags between planting and harvesting trees will complicate decisions, as adaptation may take place at multiple times during a forestry rotation (IPCC-WGII 2007).

A more holistic approach to adaptation to progressive climate change needs to be developed, which considers the interactions of different technical and policy sectors (including management innovation that increases diversification). This would allow for the development of adaptation options that go beyond sector specific management and lead to more systemic changes in resource management and allocation, such as targeted diversification of production systems and livelihoods (Howden et al., 2007).

Project 5 will identify, in Output 1, likely climate-driven spatial shifts and the best natural resource management practices for the new climate regimes. Output 2 will examine what new methods and technologies can be used to ensure crop varietal fit to the new regimes. Output 3 will develop the modelling framework for assessing adaptation pathways, and provide opportunities for on-farm and landscape-level testing of holistic adaptation strategies.

Goal and objectives

The goal of Project 5 is to identify strategies, from household to landscape level, to enhance adaptation to progressive climate change. This Project will develop, test and implement adaptation options for maintaining food security in the face of climate change effects projected over the next decades. Strengthening the adaptive capacities of farmers and other land users will encompass technical innovations such as improved germplasm for climate-related stresses, integrated NRM practices, diversification of production systems, enhanced biodiversity at landscape level and improved institutional settings.

The objectives of the Project are:

- To identify potential best natural resource management practices under changed climatic conditions.
- To develop improved methods, approaches and technologies for ensuring crop varietal fit to scenarios of variability and change.

- To identify and assess holistic adaptation strategies, from farm to landscape level, that can be taken up in the face of progressive climate change.

6.5.1. Project 5, Output 1: Analysis and modelling of potential best natural resource management practices under changed climatic conditions

Output description

Agro-ecological zones will undergo major changes in the coming decades. This Output will assess the likely climate-driven shifts so as to identify and evaluate options for managing potential shifts for priority cultivars, production systems, biodiversity resources, and pest and disease threats. Research to anticipate climate-driven spatial shifts will integrate downscaled climate projections with analysis of agro-ecological zones. It will build on and enhance existing tools and data sets used in crop improvement strategies and targeting, seed delivery targeting systems, pest management, and wild relative conservation strategies.

Where climate impacts may lead to major land use changes, research will identify and assess options to support the transitions it will impose on farmers and other actors within the food system. Research will include bio-economic modelling of expected spontaneous changes to agricultural and land use systems in the face of climate change; and study of historical adjustments to, e.g. multi-decadal climate variations.

Key research questions that will be answered in this Output include:

- How can downscaled, general circulation model (GCM)-based, near-term (i.e. 1–2 decades) information be used to identify likely shifts in agro-ecosystems?
- How can climate-driven shifts in the geographical domains of crop cultivars, crop wild relatives, pests and diseases, and beneficial soil biota be anticipated and best managed to protect food security, rural livelihoods and ecosystem services?
- What are the most promising measures in natural resources management, agricultural systems management and germplasm development to minimise farmers' vulnerability to climate change in different regions?

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 4A *Integrated Land, Water and Forest Management at a Landscape Level* and its specific goal: *To develop analytical methods and tools for the management of multiple use landscapes with a focus on sustainable productivity enhancement.*

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- New understanding about the range of likely climate-driven shifts in adaptation zones, and enhanced knowledge on the options for managing potential shifts

for priority cultivars, production systems, biodiversity resources, pest and disease threats.

- New knowledge about crop, nutrient, livestock, aquaculture, land and water management strategies that can be applied in areas suffering climate conditions equal or close to those predicted by GCM projections.

Impact pathways

A major aim of the impact pathway is to foster promotion and uptake of adaptation technologies and strategies that are appropriate to the progressively changing climatic conditions in agro-ecosystem zones. Key intermediary agencies that could promote systematic technical and policy support of adaptation technologies and strategies are funding agencies investing in poverty reduction, agricultural development and climate change adaptation; international and national development NGOs; regional agencies (e.g. SILSS, COMESA); producer associations, national extension agencies and private companies.

Some of the users of the research deliverables will be engaged in the research process itself; others will be engaged in targeted dissemination initiatives.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators and research partners will be identified in the latter part of 2009.

6.5.2. Project 5, Output 2: Improved methods, approaches and technologies for ensuring crop varietal fit to scenarios of variability and change

Output description

CCAFS adds value to ongoing and planned CGIAR investments in crop management and germplasm improvement by integrating them at landscape level with adaptation options in the policy domain. To this end, CCAFS will initiate a joint working group with institutions engaged in plant breeding, for example the Generation CP (GCP) and commodity-based CGIAR Centers, that will advise on the necessary genetic enhancement of principal food crops to multiple stresses brought about by climate change.

This Output will include a meta-analysis of previous and newly initiated multi-location trials. This analysis will improve understanding of the climate-sensitivity of existing germplasm and technology, trade-offs between yield potential, mean yields and stability of yields, and the effectiveness of alternative mechanisms of tolerance to stresses in the context of current climate variability. It will inform germplasm and management options for improved resilience to climate stress. While the analysis will capitalise on existing stations of the CGIAR and its partners, the new focus will be providing guidance to the design and implementation of new experiments on those climate risk/change aspects that have not been covered by previous programmes, for example multi-stress treatments

and alternative management practices that combine mitigation and adaptation strategies. Experimental station networks need to be strengthened through compatible field trials and measurement protocols, including characterisation of soil and meteorological parameters. Performance evaluation will take place at crop, cropping system and farming system levels.

Well-defined Target Populations of Environments (TPE) can be used to develop management support systems for breeding programmes; close collaboration with the GCP and commodity-based CGIAR Centers will be sought for capitalising on their well-established methodological framework of advanced breeding approaches. Georeferenced databases of germplasm collections will be used to identify crops and cultivars best suited to predicted conditions based on agro-ecological parameters of their places of origin.

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 2A *Maintaining and Enhancing Yields and Yield Potential of Food Staples*, and its specific goal: *Identification and development of pro-poor traits in crops*.

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- A strategic framework of plant-breeding institutions (such as the GCP and commodity-based CGIAR Centers), that addresses joint research planning of genetic enhancement of principal food crops for target regions to projected climate change stresses.
- New scientific knowledge on Target Populations of Environments (TPEs) for targeting germplasm and adapting crop improvement strategies to climate variability and change.
- Meta-analysis of previous and newly initiated multi-location trials that improves understanding of climate-sensitivity of existing germplasm and technology, trade-offs between yield potential, mean yields and stability of yields, and the effectiveness of alternative mechanisms of tolerance to stresses in the context of current climate variability.
- Recommendations for improved models and indicators of crop varietal fit to scenarios of variability and change.

Impact pathways

One aim of the work is to improve networking between CGIAR Centers and their partners for technology development and testing. This would include regular updating of adaptation strategies and routine assessment of livelihood and food insecurity risk implications of agricultural development in the context of a variable and changing climate. To reach this aim, the Centers and their partners will be engaged from the outset, in developing a strategic framework tackling joint research planning.

Another goal of this Output is to ensure that there is systematic technical and policy support for new crop

varieties that are appropriate to scenarios of variability and change. Key agencies to be engaged that are likely to take up the research results include funding agencies investing in agricultural development, poverty reduction and climate change adaptation; international and national development NGOs; regional agencies (e.g. SILSS, COMESA); producer associations, development NGOs, national extension agencies and private companies.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators and research partners will be identified in the latter part of 2009. A key partner is the Generation CP.

6.5.3. Project 5, Output 3: Identification of holistic adaptation strategies that can be taken up in the face of progressive climate change

Output description

Building on the analytical framework and tools developed in Project 1, Output 3, a suite of modelling approaches will be deployed for assessing impacts and identifying the most effective options for adaptation and the climate-induced risks that are associated with such innovations.

Components of this suite of models will be used in the overall data and integrated modelling system used for CCAFS (Figure 4).

Emphasis in this Output is on comprehensive strategies that integrate individual technological, livelihood, market and policy adaptation options. At the crop level, yield-quality models and hydrological/soil chemical models, currently under improvement to integrate the specific direct and indirect stresses of climate change, will be integrated with bio-economic modelling within a dynamic, stochastic, multiple criteria framework. The validated models will be coupled to GIS databases comprising detailed surveys of the natural resources in the target regions. To identify adaptation pathways that are robust across the range of possible realisations of climate change, the research will incorporate probabilistic, downscaled climate projections (Project 1, Output 2).

Large-scale land use change is likely during the next few decades, due not only to climate change but also to continued urbanisation, globalisation, population growth and dynamic market forces. In this Output planning horizons will be described for various types of stakeholder groups through interviews and workshops, followed by sharing of viewpoints across different sectors. Integration of traditional knowledge and local culture will facilitate stakeholder involvement and innovation.

Global climate change models can be run for different climate change scenarios and used with GEDIT to involve stakeholders in planning forthcoming mitigation and adaptation strategies. These mitigation and adaptation

strategies would aim to diversify options and provide resilience across landscapes, for example through annual crop diversity, agroforestry, timber, non-timber forest products and aquaculture options that improve human nutrition, production and livelihood stability and conserve the natural resource base.

This Output also involves participatory research to be undertaken in close collaboration with other Projects/Outputs, drawing on novel methods and approaches identified from Project 3. This Output will directly incorporate farmers' and other stakeholders' perceptions into the design of adaptation options, as well as insights derived from GEDIT as described above. Participatory work will enable researchers to identify constraints to adoption for different stakeholder groups, including women farmers, and test alternative delivery mechanisms at a pilot scale. This will be done jointly with Project 6 as a basis to assess acceptability and viability of options aiming at both adaptation and mitigation. The analysis of communication pathways and bottlenecks related to climate risk management (supplied by Project 4) can feed directly into this Output's activities as a basis for long-term, climate-informed decision making. This suite of activities and methods is designed to be integrative in nature with other CCAFS activities.

Key research questions for this Output include:

- What integrated set of models can best provide a system for selecting and testing adoption technologies?
- Given a rapidly changing environment of non-climatic drivers, what is the best approach for integrating individual technological, biodiversity management, livelihood, market adaptation and policy options into comprehensive local-level adaptation packages that exploit synergies, minimise unintended trade-offs and can readily be adjusted over time; and for accelerating their uptake?

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 4A *Integrated Land, Water and Forest Management at a Landscape Level* and its specific goal: *To develop analytical methods and tools for the management of multiple use landscapes with a focus on sustainable productivity enhancement.*

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- A suite of new management support tools for integrated natural resource management (crop, nutrient, water and land management) under progressive climate change.
- New understanding to derive comprehensive adaptation packages in the target regions using downscaled, probabilistic climate information within an integrated bio-economic modelling framework.
- Knowledge derived from field trials and evaluation of integrated, local-scale adaptation strategies.

Impact pathways

This Output intends to promote and implement adaptation options that render rural communities better able to monitor and adapt to climate variability and change, with full knowledge of the trade-offs that arise between multiple objectives of increasing food security and sustaining livelihoods and the environment. One goal is to ensure that food production is optimised and sustained in response to a changing climate. This Output aims to improve analytical and community-based methods and protocols that are applied to adapt to progressive climate change, including methods for early responses to improved long-range climate forecasts. It will ensure that innovative technologies are adopted by farmers using genetically-improved crops and livestock to enable adaptation to and mitigation of the negative impacts of climate change.

To ensure uptake of the research results a variety of intermediary agencies will be engaged. At global to regional levels this includes funding agencies investing in agricultural development, poverty reduction and climate change adaptation; international development NGOs; and regional agencies (e.g. SILSS, COMESA). At the local and national level it includes community groups, producer associations, cooperatives, development NGOs, national extension agencies and private companies.

Some of these intended users will be engaged in the research process itself while others will be reached through targeted dissemination strategies.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators, and research partners will be identified in the latter part of 2009.

6.6. Project 6: Poverty alleviation through climate change mitigation

Project overview and rationale

The poor can hardly be held accountable for climate change, but agriculture does contribute considerably to climate forcing by contributing 10–12% of total global anthropogenic emissions of greenhouse gases (Smith et al., 2007). For the non-CO₂ GHGs (principally methane and nitrous oxides), emissions are highest in developing countries and expected to grow rapidly in the coming decades (Verchot et al., 2007).

There are several ways in which improving natural resource management and agricultural systems can contribute climate benefits, while providing benefits to farmers. For example, increasing nitrogen use efficiency and improving fertiliser management can decrease soil nitrous oxide emissions, and reduce input costs for farmers. The

adoption of practices that decrease methane production in livestock often results in better feed use efficiency. Sequestering carbon in agroforestry or community forestry offers opportunities to diversify production, ensure a supply of wood for local use, and develop more sustainable energy supplies for communities. Output 1 of this project will examine ways in which agricultural production could be modified in order to mitigate climate change. To do this, Output 1 also has a methodological component: (a) developing and assessing systems for GHG monitoring and accounting at farm and landscape level and (b) validating simulation models that can be used to identify the mitigation potential of different options.

Incentive based mechanisms, such as the Clean Development Mechanism and the new UN initiative in Reducing Emissions for Deforestation and forest Degradation (REDD), as well as growing voluntary carbon markets, provide opportunities for smallholder farmers to reduce GHG emissions, move to more sustainable land management practices, and, through tapping into these new market opportunities, bolster their food and livelihood security through diversifying income sources. Critical evaluations of these win-win situations for livelihoods and the environment have been largely neglected by research (Klein et al., 2007). Output 2 will examine payments for environmental services (PES) and other institutional options for achieving win-win outcomes.

The adaptation and mitigation communities have tended to operate in isolation. Output 3 will explore mitigation synergies with the adaptation pathways identified in Projects 4 and 5, with the express objective of reducing negative impacts of tropical agriculture on the global climate system whilst supporting more sustainable rural livelihoods indirectly, through the adoption of improved practices, or directly, through the derivation of income from emerging markets for environmental services. Inevitably trade-offs exist between environmental and livelihood benefits, hence this Output will analyse these trade-offs in detail from a systems perspective (Stoorvogel et al., 2004). To do this, Output 3 will also contribute methodologically by linking adaptation and mitigation modelling techniques.

Goal and objectives

The goal of Project 6 is to identify strategies, from household to landscape level, that mitigate climate change, and to identify synergies and trade-offs between mitigation and adaptation strategies. This Project will evaluate the potential of different practices, technologies and policies on mitigating the impacts of agriculture on climate forcing which also contribute to poverty alleviation through enhanced food security and/or livelihoods.

The objectives of the Project are:

- To identify improved tools, models and technologies to enhance climate change mitigation by the rural poor.
- To identify and assess market-based instruments and other institutional arrangements that improve the uptake of mitigation strategies and benefit the poor, including female-headed households.

- To develop tools, models and principles to enhance understanding of the trade-offs and synergies between mitigation and adaptation; and among the goals of environmental sustainability, reduced emissions and livelihood improvement.

6.6.1. Project 6, Output 1: Improved tools, models and technologies to enhance climate change mitigation by the rural poor

Output description

Niles et al. (2002) identified some 390 MT of potential carbon mitigation from sustainable agricultural practices alone, many of which can enhance productivity on-farm and contribute to poverty alleviation. Furthermore, the pressures for agricultural expansion in many developing countries contribute to carbon emissions through deforestation and unsustainable land management practices, including the practice of slash and burn. Here Niles et al. (2002) flagged a possible 1.565 MT of carbon mitigation potential.

This Output will examine the C sequestration and GHG abatement potential of a variety of natural resource management approaches. A set of target practices where CCAFS can contribute to possible win-win outcomes through new partnerships and novel analytical techniques will be identified. These practices may include livestock management, agroforestry, fertiliser management and reduced tillage amongst others. For those target practices identified, this Output will undertake a full GHG emission inventory in the target regions using field studies for validating simulation models. The validated models will be used to identify mitigation potential of different management options and – in combination with GIS tools – for upscaling of GHG source strengths under different agricultural development and climate change scenarios.

To achieve the objectives of this Output, a GHG measurement and monitoring system will be developed in collaboration with suitable partners (e.g. GTOS, GEO/GEOSS). Amongst the constraints in connecting smallholder farmers to global carbon markets is the issue of monitoring and validating the reduced carbon emissions from local practices. CCAFS will develop a multi-scale GHG assessment framework using IPCC approaches. This will combine novel remote sensing techniques with the traditional field inventory measurements into a net-net GHG accounting system. This will allow implementing agencies to provide an accurate accounting of actual project carbon and non-CO₂ GHG dynamics, and report their contribution to corresponding global carbon environmental benefits. The system will be designed to quantify precision and accuracy. The remote sensing technologies and land-based inventory methodologies will be integrated into cost-effective, adaptable tools for use by a wide range of users in developing countries. Applications of these methods will provide pathways for project developers and managers to increase the realisation of those benefits through the stabilisation/increase in carbon

stocks and reduced emissions from land-use activities and land cover change.

A key research question to be addressed by this Output is:

- What is the GHG abatement potential (full net-net GHG accounting) of promising carbon sequestration and non-CO₂ GHG emissions reduction technologies and management practices?

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 4A *Integrated Land, Water and Forest Management at a Landscape Level* and its specific goal: *To develop analytical methods and tools for the management of multiple use landscapes with a focus on sustainable productivity enhancement.*

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- New systems for GHG monitoring and accounting at farm and landscape levels.
- Enhanced knowledge on the potential of reduced tillage, agroforestry, community forestry, residue management, nutrient management, improved feeding practices and other practices to both sequester carbon and/or reduce GHG emissions at landscape-level.

Impact pathways

This Output aims to ensure that mitigation technologies will be promoted by intermediary agencies and adopted by producers. It intends to facilitate systematic technical and policy support for mitigation technologies. Key intermediary agencies that are likely to take up the results include those dealing with global UNCCD and IPCC processes; funding agencies investing in agricultural development, poverty reduction and climate change mitigation; international development NGOs likely to promote mitigation options (e.g. CARE); regional agencies (e.g. SILSS, COMESA); agencies involved in markets for reduced emissions (including REDD), in particular those dealing with verifying emissions; and financial institutions providing finance for reduced emissions. At the local and national levels, key intended users are producer associations, national development NGOs and national extension agencies.

The IPGs will be tailored for different intended users, and some intended users will be engaged directly in the research itself, while others will be reached through targeted dissemination initiatives.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators, and research partners will be identified in the latter part of 2009.

6.6.2. Project 6, Output 2: Identification of market-based instruments and other institutional arrangements that

improve the uptake of mitigation strategies that benefit the poor

Output description

Payments for environmental services (PES) is an emerging field which promises to promote win-win situations for the environment and livelihoods. PES could involve direct payments from emerging carbon markets to stakeholders who reduce emissions from their agricultural activities. Other opportunities exist in emerging markets for certified products in the context of their water-use, inorganic inputs and sustainability of practices. The enhanced income from the sale of services and/or certified products may lead to improved livelihoods as well as more sustainable practices that lead to more adaptive systems or more efficient use of climate-related resources.

The identification and promotion of management options for mitigating climate change need to be underpinned by improved understanding of the impact of agricultural practices and the current agricultural policy framework on climate change. A key element in this will be developing institutions and mechanisms to support sustainable, pro-poor response options to reduce climate impacts from agriculture.

In this Output opportunities for diversified incomes from emerging markets for carbon and other environmental services will be evaluated for their potential in reducing climate forcing and enhancing food security and livelihoods. This will include critical analyses of the best means of implementing carbon-based mitigation schemes that provide benefits to smallholder farmers. Novel opportunities for incentive based schemes that reduce negative impacts on the climate system derived from agriculture will also be sought (e.g. through conservation agriculture or certification schemes for agricultural produce). These may require new public-private and public-public partnerships; for promising opportunities pilot schemes will be developed in the priority regions. Special attention needs to be paid to marginalised groups, including women, to ensure that the institutional innovations do not widen and entrench disparities.

With Projects 2 and 3, a number of regional policy analyses will be commissioned to assess the ability of countries to host C sequestration and GHG abatement projects. This will be closely linked to the scenarios exercises. Consultation with policy makers will also be undertaken at the outset and as results become available. An analysis of the existing financial mechanisms for carbon trading will also be commissioned to look at the transaction costs and to establish to what extent the rules of carbon markets preclude the participation of the poor in these markets and preclude the participation of developing countries to participate in climate change mitigation.

Some key questions to be answered in this Output include:

- What types of policies and institutional arrangements will be most conducive to providing income to

smallholder farmers, including marginalised groups, from increasing carbon sequestration on agricultural lands or reducing further carbon emissions from clearing of natural habitats?

- What are the trade-offs between payment schemes for environmental services (pro-environment) and food-security at the farm- and regional-level?

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 4A *Integrated Land, Water and Forest Management at a Landscape Level* and its specific goal: *To develop analytical methods and tools for the management of multiple use landscapes with a focus on sustainable productivity enhancement.*

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- New knowledge on the global and national policies for GHG emission reductions in the context of enabling improved adaptation of rural communities.
- Synthetic understanding about food-security-proofed payment schemes for environmental services.

Impact pathways

The impacts sought in this Output include: rural communities better adapted to climate variability and change due to diversified income portfolios derived from payment schemes for environmental services; and reduced carbon emissions from rural agricultural lands achieved through these payment schemes. This will be achieved through the proposed outcome: widespread and systematic technical and policy support for payment systems. To achieve this outcome some key intermediary agencies will be engaged, both those funding mitigation options (e.g. the World Bank, bilateral donors, the private sector involved in carbon markets) and those implementing mitigation options (e.g. large international NGOs). The Katoomba group, a global think tank on PES, will also be engaged given its role in promoting PES best practice.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators and research partners will be identified in the latter part of 2009.

6.6.3. Project 6, Output 3: Tools, models and principles to enhance understanding of the trade-offs and synergies between mitigation and adaptation; and among the goals of environmental sustainability, reduced emissions and livelihood improvement

Output description

This Output is directed at exploring the synergies and trade-offs between adaptation and mitigation strategies. In addition, it focuses on trade-off analyses amongst the goals of environmental sustainability, reduced emissions

and livelihood improvement. It will take the practices selected for study in Output 1 and will conduct a full financial and economic analysis of the improved practices and the traditional practices that will be replaced, to assess the trade-offs for farmers. Impacts of improved practices on other resources will also be evaluated.

While biofuel production offers novel opportunities for poverty alleviation and carbon offsets, the socioeconomic and environmental consequences of potentially large-scale implementation need careful analysis. There is an ongoing controversy about the mitigation potential of biofuels, with many groups asserting that biofuels for developed country markets emit more fossil fuel CO₂ than they conserve because of the extensive deforestation involved. This will be considered in the early stages through commissioning of workshops and strategy papers which will inform CCAFS of possible research opportunities where value can be added to the ongoing debate.

In many cases a win-win outcome is not feasible, so a central component of this Output is analysing the trade-offs between positive environmental outcomes and food security and livelihoods. Trade-off analyses will be conducted to examine the contribution of prospective practices or policies to reduced climate forcing and the food security and livelihood outcomes from the local to regional scale. This will include economic, social, cultural and biophysical analyses in order to quantify the broader impacts (net-net accounting) and evaluate the environmental and socioeconomic sustainability of potential intervention.

Some key questions to be answered in this Output include:

- To what extent can adaptation options contribute to carbon sequestration and mitigation of GHG emissions?
- What is the potential for mitigation reduction to contribute to reducing food security and reducing poverty?

Alignment to CGIAR System Priorities

This Output falls completely within the CGIAR System Priorities, and is mainly directed at SP 4A *Integrated Land, Water and Forest Management at a Landscape Level* and its specific goal: *To develop analytical methods and tools for the management of multiple use landscapes with a focus on sustainable productivity enhancement.*

International Public Goods

This Output will produce a set of international public goods (IPGs) that includes:

- New understanding to determine how best to address the complex GHG mitigation, food security and livelihood issues associated with biofuel production.
- Scientific knowledge on the trade-offs that exist between targeted environmental goals of payment schemes, and food security and livelihood goals at the local to regional scale.
- Validated simulation models for assessing the trade-offs and synergies amongst carbon emissions, livelihood

improvements and environmental services.

- Improved understanding of what makes win-win situations for adaptation and mitigation strategies.

Impact pathways

The impact sought by this Output is improved incomes and food security, as well as reduced carbon emissions, through the adoption of complementary adaptation and mitigation strategies. The adoption of climate-friendly land management practices is intended to contribute to greater adaptive capacity of agricultural systems. The IPGs will be directed to policy-makers, amongst others, so that decisions are based on accurate information about the impacts that policy options have on GHG mitigation and food security. The IPGs will also be tailored to other audiences, most notably those implementing adaptation and mitigation strategies on the ground. To achieve widespread adoption major international NGOs, regional organisations and funding agencies that promote mitigation-adaptation options will be targeted.

Roles of partners

As CCAFS is a collaborative initiative, the research will be conducted through an extensive array of partners. Key partners will be the CGIAR or ESSP partners engaged in this Project. Theme Leaders, Regional Facilitators and research partners will be identified in the latter part of 2009.

Appendix 1. CCAFS Provisional Project Logframes¹

Logframe for Project 1: Diagnosing vulnerability and analysing opportunities

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
Output 1:	Establishment, through scenario analysis, of a coherent set of scenarios that examines potential development scenarios under a changing climate and differing pathways of economic development		Global Adaptation Fund, UNREDD, the World Bank, IPCC, UNFCCC/SBSTA, key bilateral donors developing adaptation and mitigation strategies, large international NGOs entering this arena (e.g. CARE International), key regional and national actors (e.g. for Eastern Africa COMESA)	Appropriate adaptation and mitigation strategies, and climate variability and climate change issues mainstreamed into national, regional and international agricultural development strategies and institutional agendas	Food security enhanced and emissions reduced in smallholder farming areas
Output Targets 2010	Identification of key regional climate and policy issues, and development of prototype scenarios	<ul style="list-style-type: none"> ■ International Launch Conference where prototype scenarios are discussed ■ Document: Characterisation for three target regions of the key trends in agricultural production, food security, land-use change, poverty levels, and soil, water and other supporting ecosystem services, that provide a broad context for CCAFS (with Projects 4 and 5) ■ Document: Regional focal studies on what is known about historic and projected climate change impacts, other research and development efforts on potential climate adaptation or risk management interventions, other 	Research, development and policy audiences	Key mitigation and adaptation pathways selected for further research, development and advocacy	More targeted research and development undertaken on specific adaptation and mitigation pathways

¹ Given that this is the first MTP, some of the activities and deliverables in the original proposal have been captured as Output Targets for 2013 – while the MTP process only requires that we go as far as 2012, we have included 2013 Output Targets so that we don't lose some of the longer term intentions and can use this document as an element of the strategic planning that will be conducted when the CCAFS team is in place.

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
		<p>major drivers of change in agricultural and food systems, significant institutions and relevant policy processes</p> <p>■ Outlines for a set of four prototype scenarios based on an initial stakeholder consultation workshop involving regional scientists and policymakers, and further elaborated prototypes developed in follow-up writing exercise by regional authors</p>			
Output Targets 2011	Development of semi-quantified regional scenarios that have been rolled out with key regional stakeholders	<p>■ Regional reports describing developments per scenario for key aspects of the regions' agricultural and food systems; systematic assessments of agricultural and food security developments per scenario based on adaptation and mitigation pathways (particular data needs will be satisfied by Projects 2, 4, 5 and 6)</p> <p>■ Regional Fora to discuss and map out a first indication of which response options and adaptation and mitigation strategies might be conceivable and viable to best strengthen regional food security under various scenarios</p>	Research, development and policy audiences	Key mitigation and adaptation pathways selected for further research, development and advocacy	More targeted research and development undertaken on specific adaptation and mitigation pathways
Output Targets 2012	Coherent set of quantified development scenarios under a changing climate and differing pathways of economic development, used to identify livelihood opportunities and threats regionally	<p>■ Media reports, policy briefs and journal articles on regional scenarios for agriculture and food security under a changing climate</p> <p>■ Guidelines and journal article on best practice in conducting scenario analysis, including perspectives on how to better integrate women in the engagement process</p>	Global investors in adaptation and mitigation; and major global and regional development actors	Appropriate adaptation and mitigation strategies, and climate variability and climate change issues mainstreamed into national, regional and international agricultural development strategies and institutional agendas	Food security enhanced and emissions reduced in smallholder farming areas
Output 2:	Identification of climate trends and variability, and assessment of methods for downscaling climate change information for		National meteorological services, the African Centre of Meteorological Applications for Development	■ Use of outputs to better target downscaled climate change information to the needs of users of such information; use of	Vulnerability in the face of climate change reduced for poor rural dwellers

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
		agriculture and natural resources management	(ACMAD), regional organisations (e.g. CILSS), agricultural research agencies (including CGIAR and NARS), and agencies planning adaptation strategies (e.g. bilateral funding agencies, government, large international NGOs)	knowledge on climate change trends and variability to better design adaptation strategies ■ Reorienting mandate and data policy of national meteorological services toward delivering climate information products and services through extension services that can contribute toward greater climate awareness and proactive decision-making for a wide range of stakeholders	
Output Targets 2010	Characterise recent trends and variability in climate for the study regions and the ability of climate models to simulate these features	■ Project reports characterising trends (2010) ■ Journal article on ability of models to simulate trends	National meteorological services, the African Centre of Meteorological Applications for Development (ACMAD), regional organisations (e.g. CILSS), agricultural research agencies (including CGIAR and NARS), and agencies planning adaptation strategies (e.g. bilateral funding agencies, government, large international NGOs)	■ Use of outputs to better target downscaled climate change information to the needs of users of such information; use of knowledge on climate change trends and variability to better design adaptation strategies ■ Research better targeted to adaptation strategies that are appropriate for the likely climate trends	Vulnerability in the face of climate change reduced for poor rural dwellers
Output Targets 2011	Assess and adopt methods for downscaling climate change information specifically for agriculture and natural resources management	■ Assessment report that includes: use of a range of timescales varying from the diurnal to multi-decadal; quantification of the spatial and temporal limits to prediction; and quantification of the uncertainties associated with these methods ■ Report on how the adopted methods for downscaling reflect the information needs of different stakeholders (with Project 3)	Researchers dealing with climate change, both from meteorological agencies as well downstream users of climate change information	Research better targeted to adaptation strategies that are appropriate for the likely climate trends	Research and data products better tailored to the emerging realities in terms of likely climate trends
Output 3:	Integrated assessment framework and toolkit to enhance capability to assess climate change impacts on agricultural systems and their supporting natural resources, and analysis of likely effects of specific adaptation and mitigation options		Numerous agencies involved in planning for and researching climate change impacts on agriculture and natural resource management (Global Adaptation Fund, UNREDD, the World Bank, IPCC, UNFCCC/SBSTA, key bilateral donors, large	Increased uptake of appropriate options in the regional sites and their homologues; trade-offs use a coherent analytical framework to chart the efficacy of different adaptation and mitigation options	Food security enhanced and emissions reduced in smallholder farming areas

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
			international NGOs, key regional and national actors (e.g. COMESA, CILSS, CGIAR, NARS)		
Output Targets 2010	Development of a conceptual framework, to guide the development of an integrated suite of appropriate models, methods and databases	Conceptual model, based as far as possible on existing work (prepared and discussed at Launch conference)	Researchers dealing with climate change and mitigation strategies	Research better targeted to adaptation strategies that are appropriate for the likely climate trends	Research products better tailored to the needs of poor rural dwellers in terms of reducing vulnerability and enhancing food security
Output Targets 2011	Identification of baseline indicators for the benchmark sites, development of a data integration system and establishment of baseline data	<ul style="list-style-type: none"> ■ Case study countries, benchmark research locations and national and local institutional partners selected, in conjunction with regional fora ■ Indicative data integration and modelling framework developed, with final proposal made for database architecture ■ Repository of information on vulnerable populations now and in the future, tailored to characterising benchmark sites and scaling up place-based outputs ■ Baseline indicators for the case-study sites (with Projects 4–6 collecting some of the data) (designed also to cater for <i>ex-post</i> impact assessment of the CCAFS) 			
Output Targets 2012	<ul style="list-style-type: none"> ■ Integrated assessment framework, toolkit and resultant indicators to enhance capability to assess climate change impacts on agricultural systems and their supporting natural resources ■ Analysis of likely effects of specific adaptation and mitigation options in three target regions ■ Set of information products on likely climate change impacts on agricultural systems, and promising adaptation and mitigation options 	<ul style="list-style-type: none"> ■ Special Issue of journal detailing the overall framework and its elements ■ Toolkit, including an integrated suite of appropriate models (with specialist inputs from Projects 2, 4, 5 and 6), methods and databases, with a focus on evaluating the trade-offs between impacts of climate change on livelihoods, food security, and the environment (toolkit designed to carry out specific <i>ex-ante</i> impact assessment studies and priority-setting activities as required by the other Projects) ■ Media reports, policy briefs and journal articles on the impacts of specific 	Numerous agencies involved in funding, planning for and researching climate change impacts on agriculture and natural resource management	The formulation of a responsive and effective international research and donor agenda for the next two decades, as a result of a comprehensive assessment of the state-of-the-art concerning climate change impacts on agriculture and the food system, that identifies key knowledge and data gaps	Food security enhanced and emissions reduced in smallholder farming areas

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
		adaptation and mitigation options			

Logframe for Project 2: Unlocking the potential of macro-level policies

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
Output 1:	Improved approaches, tools and databases for assessing the impacts of macro-level policies on adaptation and mitigation strategies		Global and regional economic think tanks and national and regional planning agencies, involved in developing macro-level policies and climate change adaptation and mitigation strategies	Use of improved approaches and tools to assess the impacts of macro-level policies under different climate change and development scenarios	Better macro-level policy environment leading to reduced vulnerability of rural dwellers in conjunction with reduced emissions from smallholder farming areas
Output Targets 2011	Development of an integrated package of approaches to assess the impacts of macro-level policies, involving (i) detailed databases; (ii) models uniting economic and biogeophysical dynamics of agricultural production, with downscaled climate change scenarios; and (iii) established integrated assessment models for climate change, but incorporating earth system dynamics	<ul style="list-style-type: none"> Journal article on framework for integrated approaches to assess the impacts of macro-level policies Regional fora to get feedback on integrated packages 	Researchers in global and regional economic think tanks and national and regional planning agencies, involved in developing macro-level policies and climate change adaptation and mitigation strategies	More targeted research on the elements of the integrated framework that have knowledge gaps	
Output Targets 2012	Develop a global general equilibrium model that links changes in agriculture and food systems to other key sectors of the economy	<ul style="list-style-type: none"> Report and contribution to a Special Issue on this Project describing the model and how the approach enables the study of linkages and trade-offs among agricultural markets, land use, the economy, and soil, vegetation and water as they affect carbon balance and the major nutrient cycles 	Researchers in global and regional economic think tanks and national and regional planning agencies, involved in developing macro-level policies and climate change adaptation and mitigation strategies	Improved recommendations for macro-level policies	
Output Targets 2013	Comprehensive, searchable digital library for the macro-policy Project that integrates findings, literature, ideas for scientists and policy makers, tailored to adaptation planning and mainstreaming activities	<ul style="list-style-type: none"> Web 2 digital library Journal article describing the novel approaches used in the digital library 	Researchers in global and regional economic think tanks and national and regional planning agencies, involved in developing macro-level policies and climate change adaptation and mitigation strategies	Improved recommendations for macro-level policies	Better macro-level policy environment leading to reduced vulnerability of rural dwellers in conjunction with reduced emissions from smallholder farming areas
Output 2:	Recommendations for macro-level policies that provide opportunities for adaptation and		Global Adaptation Fund, UNREDD, the World Bank, IPCC, UNFCCC/SBSTA, key bilateral donors	Adoption of macro-level policies and strategies by governments and agencies involved in	Food security enhanced and emissions reduced in smallholder farming areas

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
	mitigation strategies		developing adaptation and mitigation strategies, large international NGOs entering this arena (e.g. CARE International); global and regional economic think tanks and national and regional planning agencies, involved in developing macro-level policies (e.g. for Eastern Africa COMESA); regional information networks, pro-poor civil society organisations	developing adaptation and mitigation strategies	
Output Targets 2010	Scenarios for analysis of international and national policy shifts, institutional innovations, and concrete investments that could be integrated to support mitigation and adaptation strategies	<ul style="list-style-type: none"> ■ Initial policy forum and dialogue (at Regional Fora and Launch Conference) that highlight the need to act on the climate challenge without undermining other important rural development and environmental goals ■ Three regional policy analyses: Scenarios for analysis of international and national policy shifts, institutional innovations, and concrete investments that could be integrated to support mitigation and adaptation strategies (with Project 1, 3 and 6), and used to guide key features of the integrated approach 	Research, development and policy audiences	Key mitigation and adaptation pathways selected for further research, development and advocacy	More targeted research and development undertaken on specific adaptation and mitigation pathways
Output Targets 2011	Analysis and identification of the opportunities as well as constraints inherent in macro-level policies	<ul style="list-style-type: none"> ■ Report, journal article and media releases that quantify the capacity of the Earth system to provide the resources necessary under selected macro-economic policies, and thereby assess the long-term capacity of the environment to deliver these ecosystem services and ensure rural livelihoods on a multi-decadal basis ■ Regional Policy forums to share results and seek feedback ■ Synthesis report on how gender has been addressed in the policy engagement process 	Global Adaptation Fund, UNREDD, the World Bank, IPCC, UNFCCC/SBSTA, key bilateral donors developing adaptation and mitigation strategies, large international NGOs entering this arena (e.g. CARE International); global and regional economic think tanks and national and regional planning agencies, involved in developing macro-level policies (e.g. for Eastern Africa COMESA); regional information networks, pro-poor civil society organisations	Adoption of macro-level policies and strategies by governments and agencies involved in developing adaptation and mitigation strategies	Food security enhanced and emissions reduced in smallholder farming areas

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
Output Targets 2012	Analysis of the potential for adaptation and mitigation policies to enhance developing-country agricultural growth, food security, poverty reduction, and environmental sustainability	<ul style="list-style-type: none"> ■ Regional Policy fora and dialogue ■ Report and contributions to a Special Issue that assesses the impact of carbon taxes and alternative cap-and-trade regimes on developing-country agricultural and economic growth, food security, poverty, and environmental sustainability based on scenario analysis linking general equilibrium models with detailed agricultural (crop, livestock, and forestry) partial equilibrium models and integrated assessment (with Project 1, Output 3; and Project 6, Output 3) ■ Policy briefs and global policy dialogue to examine the implications for climate change of international and national strategic agricultural development policies and the need for adaptation policies beyond 'good development policy' 	Global Adaptation Fund, UNREDD, the World Bank, IPCC, UNFCCC/SBSTA, key bilateral donors developing adaptation and mitigation strategies, large international NGOs entering this arena (e.g. CARE International); global and regional economic think tanks and national and regional planning agencies, involved in developing macro-level policies (e.g. for Eastern Africa COMESA); regional information networks, pro-poor civil society organisations	Adoption of macro-level policies and strategies by governments and agencies involved in developing adaptation and mitigation strategies	Food security enhanced and emissions reduced in smallholder farming areas

Logframe for Project 3: Enhancing engagement and communication for decision-making

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
Output 1:	Identification of key actors, their information needs and the institutional and decision-making context for uptake of policy recommendations and technical practices for adaptation and mitigation		Researchers undertaking climate change research in the context of poverty and food insecurity, from national to global level: NARS, national to global think tanks, ARIs, CGIAR	Better targeted research information to the appropriate actors; information that is tailored to the institutional and decision making context	Food security enhanced and emissions reduced in smallholder farming areas
Output Targets 2010	Analysis of the role of the existing policy and institutional environment on dissemination and uptake of promising adaptation strategies, and identification of opportunities for improving uptake in the selected countries and regions	<ul style="list-style-type: none"> ■ Report and journal paper: Actor analysis and institutions mapping relevant to agriculture, food security and adaptation to climate change in specific contexts; identification of the factors that constrain institutional actions 	Researchers undertaking climate change research in the context of poverty and food insecurity, from national to global level: NARS, national to global think tanks, ARIs, CGIAR	Better understanding of the policy and institutional contexts on uptake of scientific information	Better designed dissemination and engagement strategies

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
		<ul style="list-style-type: none"> ■ Initial case study reports based on case studies drawn from Projects 1, 2, 4, 5 and 6 			
Output Targets 2011	Analysis of the existing research delivery systems and bottlenecks for agricultural and climate information	<ul style="list-style-type: none"> ■ Web-based document and journal article on the options to enhance perception, communication and use of probabilistic climate projections ■ Journal article on how institutional actions interact with local knowledge, values, beliefs, and cultural factors to facilitate or constrain responses to climate change (based on case study drawn from Project 4 themes) ■ Case study reports and synthesis journal article, on the participatory development of climate information products and communication processes, including an assessment of the use and impact of such work 	Researchers undertaking climate change research in the context of poverty and food insecurity, from national to global level: NARS, national to global think tanks, ARIs, CGIAR	Better understanding of the bottlenecks for agricultural and climate information	Better designed delivery systems for new findings on mitigation and adaptation strategies
Output Targets 2012	Comparative analysis on the decision-making (or policy) context for key issues, particularly the use of information and the role of research in supporting or contributing to decisions	<ul style="list-style-type: none"> ■ Historical case studies that look at instances of very risky decisions and the role of research in these decisions, including lessons learned about institutions and decision-making (with case study material derived from themes in Projects 1, 2, 4, 5 and 6) ■ Media release, policy brief and supporting articles in a Special Issue on this Project directed at key scientific audiences to foster uptake of results ■ Report on the role of women in decision-making related to climate change adaptation and mitigation 	Researchers undertaking climate change research in the context of poverty and food insecurity, from national to global level: NARS, national to global think tanks, ARIs, CGIAR	Better understanding of the decision making context in relation to adaptation and mitigation strategies	Better designed research strategies that meet the needs of decision makers
Output Targets 2013	Recommendations for enhanced climate information products, communication protocols, training materials for intermediaries, and	<ul style="list-style-type: none"> ■ Impact study on the use of climate information products and services in case study locations (drawing also on case studies conducted in 	National meteorological services, the African Centre of Meteorological Applications for Development (ACMAD), regional organisations (e.g. CILSS), agricultural	Effective rural climate information services initiated, supported and evaluated in target regions	Reduced vulnerability to climate shocks and variability

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
	institutional delivery mechanisms for rural communities	Project 4, Output 2) ■ Brochures and guidelines for producing climate information	research agencies (including CGIAR and NARS), and agencies planning adaptation strategies (e.g. bilateral funding agencies, government, large international NGOs)		
Output 2:	Tools, guidelines and approaches that enhance researcher–stakeholder interaction and the uptake of scientific outputs, including from CCAFS		Researchers undertaking climate change research in the context of poverty and food insecurity, from national to global level: NARS, international NGOs) national to global think tanks, ARIs, CGIAR	New approaches to researcher–stakeholder interaction adopted leading to improved targeting of research and improved uptake of research results by stakeholders	Enhanced food security and reduced emissions from smallholder farming areas
Output Targets 2011	Identification of new approaches for enhancing science-policy dialogues that account for multiple perspectives and dynamic contextual factors, for multiple levels of decision-making	<ul style="list-style-type: none"> ■ Comparative case studies based on different models (e.g. participatory, boundary organisations, integral, or learning) of researcher–stakeholder interaction, followed by a longitudinal analysis of adaptation practices and their social and environmental consequences ■ Report and journal article documenting iterative learning processes and dialogues with stakeholders, where approaches and outputs as well as research questions are continually refined (with Project 1 and 2 themes) ■ Workshops to evaluate and assess the state-of-knowledge on researcher–stakeholder interactions 	Researchers undertaking climate change research in the context of poverty and food insecurity, from national to global level: NARS, national to global think tanks, ARIs, CGIAR	New approaches to researcher–stakeholder interaction researched	
Output Targets 2012	Identification of sustainable adaptation pathways in case studies of researcher–stakeholder interaction	Articles in Special Issue on this Project that cover the development, testing and evaluation of new models of researcher–stakeholder interaction that specifically addresses decision-making and responses to climate change	Researchers undertaking climate change research in the context of poverty and food insecurity, from national to global level: NARS, national to global think tanks, ARIs, CGIAR	New approaches to researcher–stakeholder interaction adopted	
Output Targets 2013	Improved tools and recommendations for integrating policy objectives and climate and environmental issues that are	Toolkit and policy recommendations for integrating climate and environmental issues	Researchers undertaking climate change research in the context of poverty and food insecurity, from national to global level:	New tools and recommendations widely used in research community such that key stakeholders driving the mitigation and	Enhanced food security and reduced emissions from smallholder farming areas

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
	implemented and used		NARS, national to global think tanks, ARIs, CGIAR	adaptation agenda make decisions based on new scientific results	

Logframe for Project 4: Adaptation pathways based on managing current climate risk

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
Output 1:	Identification of crop cultivar and rural livelihood portfolios that buffer against climate shocks and enhance livelihood resilience		<p>At global to regional levels: funding agencies investing in agricultural development, poverty reduction and climate change adaptation; international development NGOs; regional agencies (e.g. SILSS, COMESA).</p> <p>At the local and national level: producer associations, development NGOs, national extension agencies, private companies</p>	<ul style="list-style-type: none"> ■ New crop cultivar and livelihood portfolios promoted by development and funding agencies, and by civil society groups and the private sector ■ Systematic technical and policy support for increasingly diversified farming systems and rural economies that buffer against climate shocks and enhance livelihood resilience 	Increasingly diversified farming systems and rural economies that buffer against climate shocks and enhance livelihood resilience
Output Targets 2011	Inventory and assessment of existing germplasm, production and natural resources management (NRM) technology for climate sensitivity, and assessment of the gaps and priorities for future technology development with respect to projected climate change	<ul style="list-style-type: none"> ■ Web based inventory of existing technologies ■ Research strategy to fill existing gaps in knowledge ■ Media release, policy brief and supporting journal article directed at key scientific audiences, and associated dissemination with funding agencies, to foster new directions in research 	Research organisations and funding agencies	New research targeted to address the gaps identified	
Output Targets 2012	Analysis of climate resilience of improved crop and livelihood diversification strategies	<ul style="list-style-type: none"> ■ Journal article on the climate resilience of improved strategies ■ Major dissemination push to get results out, from national to global levels, taking advantage of the networks that already exist 	Agencies investing in agricultural development, poverty reduction and climate change	New crop cultivar and livelihood portfolios promoted by development and funding agencies, and by civil society groups and the private sector	Increasingly diversified farming systems and rural economies that buffer against climate shocks and enhance livelihood resilience
Output Targets 2013	Recommendation identifying feasible, effective and acceptable diversified crop cultivar and rural livelihood portfolios	Policy briefs, media releases and policy briefings targeted at intended users	Agencies investing in agricultural development, poverty reduction and climate change	New crop cultivar and livelihood portfolios promoted by development and funding agencies, and by civil society groups and the private sector	Increasingly diversified farming systems and rural economies that buffer against climate shocks and enhance livelihood resilience
Output 2:	Analysis and evaluation of index-based risk transfer products to protect and enhance rural livelihoods		<ul style="list-style-type: none"> ■ Financial institutions potentially providing such products; global, regional and national agencies that can promote such products (e.g. 	<ul style="list-style-type: none"> ■ New risk transfer products promoted by development and funding agencies, and by civil society groups and the private sector 	

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
			<p>World Bank, COMESA, SILSS, national extension agencies); civil society actors promoting poverty alleviation initiatives</p> <ul style="list-style-type: none"> Agencies dealing with climate risk management (e.g. regional climate centres, national meteorological services, universities, government extension agencies; regional development agencies) 	<ul style="list-style-type: none"> Climate risk management incorporated into regional agricultural development strategies and agendas of NARS and other relevant institutions Enhanced participation of financial market institutions in pro-poor, adaptive, climate-informed services in target regions 	
Output Targets 2011	Analysis of targeting, implementation and impacts of financial risk transfer products	<ul style="list-style-type: none"> Report on the most effective design and delivery mechanisms for rural climate information products and services that support risk management at a local scale Policy briefs: Recommendations on new institutional arrangements and policy interventions that are needed to scale up risk transfer products, especially to marginalised groups including female-headed households 	Financial institutions potentially providing such products; global, regional and national agencies that can promote such products; civil society actors promoting poverty alleviation initiatives	Enhanced participation of financial market institutions in pro-poor, adaptive, climate-informed services in target regions	Vulnerability to climate shocks of poor rural dwellers reduced
Output Targets 2012	Synthesised knowledge of how to most effectively target and upscale index-based risk transfer products to protect and enhance rural livelihoods, especially those of marginalised groups, including female-headed households	<ul style="list-style-type: none"> Journal article on the climate resilience of improved strategies, and how they are appropriate for marginalised groups Major dissemination effort (media, policy briefs, direct engagement) to get the results into the hands of the intended users 	Financial institutions potentially providing such products; global, regional and national agencies that can promote such products; civil society actors promoting poverty alleviation initiatives	Enhanced participation of financial market institutions in pro-poor, adaptive, climate-informed services in target regions	Vulnerability to climate shocks of poor rural dwellers reduced
Output 3:	Identification of improved modalities and approaches for managing climate risk through the food storage, trade and distribution system		Funding agencies investing in agricultural trade issues and infrastructure; agencies dealing with international, regional and national trade treaties and agreements; international development NGOs; regional development agencies (e.g. SILSS, COMESA); private sector investing in trade and marketing systems; civil society	<ul style="list-style-type: none"> New food storage, trade and distribution systems promoted by development, trade and funding agencies, and by civil society groups and the private sector Enhanced, climate-informed management of food storage, trade and delivery for food and livelihood security in target regions 	Vulnerability to climate shocks of poor rural dwellers reduced

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
			organisations dealing with trade issues	■ Establishment of platforms for high-level coordination of climate information services, agricultural development, and disaster (e.g. food crisis) early warning and response organisations	
Output Targets 2011	Analysis and assessment the options for managing climate risk through the food storage, trade and distribution system	<ul style="list-style-type: none"> ■ Report and journal article on the institutional analysis and equilibrium modelling of climate risk management opportunities through food distribution, storage, trade and crisis response ■ Prioritised strategy, and associated media releases, for managing climate risk through the food storage, trade and distribution system 	Funding agencies investing in agricultural trade issues and infrastructure; agencies dealing with international, regional and national trade treaties and agreements; international development NGOs; regional development agencies (e.g. SILSS, COMESA); private sector investing in trade and marketing systems; civil society organisations dealing with trade issues	Enhanced, climate-informed management of food storage, trade and delivery for food and livelihood security in target regions	Vulnerability to climate shocks of poor rural dwellers reduced
Output Targets 2012	Recommendations for enhanced early warning systems for managing climate risk through the food storage, trade and distribution system	<ul style="list-style-type: none"> ■ Report evaluating early warning systems ■ Policy brief and media releases on enhanced early warning system, in association with key events 	Funding agencies investing in agricultural trade issues and infrastructure; agencies dealing with international, regional and national trade treaties and agreements; international development NGOs; regional development agencies (e.g. SILSS, COMESA); private sector investing in trade and marketing systems; civil society organisations dealing with trade issues	Enhanced early warning systems adopted	Vulnerability to climate shocks of poor rural dwellers reduced

Logframe for Project 5: Adaptation pathways under progressive climate change

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
Output 1:	Analysis and modelling of potential best natural resource management practices under changed climatic conditions		At global to regional levels: funding agencies investing in agricultural development, poverty reduction and climate change adaptation; international development NGOs; regional agencies (e.g. SILSS, COMESA). At the local and national level: producer associations, development NGOs, national extension	<ul style="list-style-type: none"> ■ Adaptation pathways appropriate to changed agroecological zones promoted by development and funding agencies, and by civil society groups and the private sector ■ Systematic technical and policy support for adaptation pathways that are 	Vulnerability to progressive climate change of poor rural dwellers reduced

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
			agencies, private companies	appropriate to the progressively changing climatic conditions in agroecological zones	
Output Targets 2010	Analysis of current scientific knowledge about crop, nutrient, livestock, aquaculture, land and water management strategies successfully applied in areas suffering climate conditions equal or close to those predicted by GCM projections	<ul style="list-style-type: none"> ■ Regional case study reports ■ Review of knowledge published on the web ■ Media releases in conjunction with major scientific meetings 	Research organisations (from global to national) and funding agencies	New research targeted to potential technologies that would be appropriate to progressively changing climate	
Output Targets 2011	Analysis to derive site-similarity and agroecological zone maps for determining best management practices under changed climatic conditions	<ul style="list-style-type: none"> ■ Report on near-term climate change projections for benchmark sites, including multi-scale uncertainty analysis ■ Media release, policy brief and supporting journal article directed at key scientific audiences to foster uptake of results 	Research organisations (from global to national) and funding agencies	New research targeted to address the likely changes that will occur in agroecological zones	
Output Targets 2012	Modelling the range of likely climate-driven shifts in adaptation zones, to identify and assess options for managing potential shifts for priority cultivars, production systems, biodiversity resources, pest and disease threats	<ul style="list-style-type: none"> ■ Inventory of climate data, agro-ecological zoning information systems and other relevant data sets ■ Journal article on likely adaptation pathways for NRM in changing agroecological zones 	Agencies investing in agricultural development, poverty reduction and climate change	Systematic technical and policy support for adaptation pathways that are appropriate to the progressively changing climatic conditions in agroecological zones	Vulnerability to progressive climate change of poor rural dwellers reduced
Output 2:	Improved methods, approaches and technologies for ensuring crop varietal fit to scenarios of variability and change		<p>At global to regional levels: funding agencies investing in agricultural development, poverty reduction and climate change adaptation; international development NGOs; regional agencies (e.g. SILSS, COMESA).</p> <p>At the local and national level: producer associations, development NGOs, national extension agencies, private companies</p>	Systematic technical and policy support for new crop varieties that are appropriate to scenarios of variability and change	Vulnerability to progressive climate change of poor rural dwellers reduced
Output Targets 2010	Strategic framework with plant-breeding institutions (such as the GCP and commodity-based CGIAR Centres) that addresses joint research planning of genetic enhancement of principal food crops for target regions to	<ul style="list-style-type: none"> ■ Strategic framework ■ Media release, policy brief and supporting journal article directed at key scientific audiences to foster uptake of results 	Research organisations dealing with plant breeding (from global to national) and funding agencies	<ul style="list-style-type: none"> ■ New research targeted to address the gaps identified ■ Improved networking established between CGIAR Centres and their partners for technology development and testing 	

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
	projected climate change stresses				
	Meta-analysis of previous and newly initiated multi-location trials that improves understanding of climate-sensitivity of existing germplasm and technology, trade-offs between yield potential, mean yields and stability of yields, and the effectiveness of alternative mechanisms of tolerance to stresses in the context of current climate variability	<ul style="list-style-type: none"> ■ Meta analysis report ■ Report discussing the problems in doing the meta-analysis and new research protocols amongst experimental stations and research agencies developed to enhance ability to doing meta-analysis ■ Journal article summarising findings in the meta-analysis 	Research organisations dealing with plant breeding (from global to national) and funding agencies	<ul style="list-style-type: none"> ■ New research targeted to address the gaps identified ■ Improved networking established between CGIAR Centres and their partners for technology development and testing 	
Output Targets 2011	Joint characterisation of Target Populations of Environments (TPEs) for targeting germplasm and adapting crop improvement strategies to climate variability and change	<ul style="list-style-type: none"> ■ Journal paper, and associated working papers, prepared jointly with Generation CP ■ Policy brief and media release jointly with Generation CP 	Research organisations dealing with plant breeding (from global to national) and funding agencies	New research targeted to address the gaps identified	
Output Targets 2012	Recommendations for improved models and indicators of crop varietal fit to scenarios of variability and change	<ul style="list-style-type: none"> ■ Journal article on improved models and indicators of crop varietal fit ■ Major dissemination effort to get results out, from national to global levels, taking advantage of the networks that already exist 	Agencies investing in agricultural development, poverty reduction and climate change	Systematic technical and policy support for new crop varieties that are appropriate to scenarios of variability and change	Vulnerability to progressive climate change of poor rural dwellers reduced
Output 3:	Identification of holistic adaptation strategies that can be taken up in the face of progressive climate change		<p>At global to regional levels: funding agencies investing in agricultural development, poverty reduction and climate change adaptation; international development NGOs; regional agencies (e.g. SILSS, COMESA).</p> <p>At the local and national level: producer associations, development NGOs, national extension agencies, private companies</p>	<ul style="list-style-type: none"> ■ Holistic adaptation strategies appropriate to progressively changing climate promoted by development and funding agencies, and by civil society groups and the private sector ■ Systematic technical and policy support for new holistic adaptation strategies 	Vulnerability to progressive climate change of poor rural dwellers reduced
Output Targets 2011	Analyses to derive comprehensive adaptation packages in the target regions using downscaled, probabilistic climate information within an integrated bio-economic modelling framework	<ul style="list-style-type: none"> ■ Established research network of CGIAR Centers, their partners and other agricultural stakeholders working to better target, develop, and update adaptation technologies ■ Expert feedback on proposed adaptation strategies 	Research organisations dealing with climate change adaptation and funding agencies	New research targeted to address the gaps identified	

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
Output Targets 2012	Analysis and evaluation of integrated, local-scale adaptation strategies	<ul style="list-style-type: none"> ■ Field reports on testing of adaptation strategies (that include attention to how such strategies are relevant to marginalised groups, including women) ■ Journal article on the climate resilience of improved strategies ■ Major dissemination effort to get results out, from national to global levels, taking advantage of the networks that already exist 	Agencies investing in agricultural development, poverty reduction and climate change	Systematic technical and policy support for the widespread testing of identified holistic adaptation strategies	Vulnerability to progressive climate change of poor rural dwellers reduced
Output Targets 2013	Suite of new management support tools for integrated natural resource management (crop, nutrient, water and land management) under progressive climate change		Agencies investing in agricultural development, poverty reduction and climate change	Systematic technical and policy support for new holistic adaptation strategies identified using the management support tools	Vulnerability to progressive climate change of poor rural dwellers reduced

Logframe for Project 6: Poverty alleviation through climate change mitigation

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
Output 1:	Improved tools, models and technologies to enhance climate change mitigation by the rural poor		<p>At global to regional levels: agencies dealing with global processes of UNCCD and IPCC; funding agencies investing in agricultural development and poverty reduction and climate change mitigation; international development NGOs; regional agencies (e.g. SILSS, COMESA); agencies involved in markets for reduced emissions (including REDD), in particular those dealing with verifying emissions; financial institutions providing finance for reduced emissions</p> <p>At the local and national level: producer associations, national development NGOs, national extension agencies</p>	<ul style="list-style-type: none"> ■ Mitigation technologies promoted by intermediary agencies and adopted by producers ■ Systematic technical and policy support for mitigation technologies 	Reduced carbon emissions from rural agricultural lands due to innovative mitigation technologies
Output Targets 2011	<ul style="list-style-type: none"> ■ New systems for GHG monitoring and accounting at farm and landscape levels ■ Validated simulation models for assessing 	<ul style="list-style-type: none"> ■ Toolbox of methods for GHG accounting ■ Journal article on approaches to GHG accounting ■ Journal article on 	Agencies grappling with the problems of verifying carbon emission reductions for the carbon market (e.g. financial institutions,	Methods taken up by intended users for promoting new mitigation options	New mitigation options taken up in target regions

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
	the mitigation potential of alternative management practices	structure and use of simulation models for assessing mitigation potential of alternative practices	verifying agencies) and agencies making choices amongst possible mitigation technologies (e.g. international and national NGOs, regional and national development agencies)	Methods taken up by intended users for promoting new mitigation options	New mitigation options taken up in target regions
Output Targets 2012	Analysis of the potential of reduced tillage, agroforestry, community forestry, residue management, nutrient management, improved feeding practices and other practices to both sequester carbon and/or reduce GHG emissions at landscape-level, and alleviate poverty	<ul style="list-style-type: none"> Journal articles on the sequestration potential and economics of promising technologies with potential to reduce GHG emissions Policy briefs, media releases at a UNCCD COP and targeted engagement of key stakeholders 	Agencies investing in agricultural development, poverty reduction and climate change mitigation	Systematic technical and policy support for the widespread testing of potential mitigation options	Reduced carbon emissions from rural agricultural lands due to innovative mitigation technologies
Output 2:	Identification of market-based instruments and other institutional arrangements that improve the uptake of mitigation strategies that benefit the poor		<p>At global to regional levels: agencies dealing with global processes of UNCCD and IPCC; international development NGOs (e.g. CARE); agencies promoting PES (e.g. the Katoomba group); regional agencies (e.g. SILSS, COMESA); agencies involved in markets for reduced emissions (inc. REDD); financial institutions providing finance for reduced emissions</p> <p>At the local and national level: producer associations, development NGOs, national extension agencies, private companies</p>	<ul style="list-style-type: none"> Payment systems promoted by intermediary agencies and adopted by producers of environmental services Systematic technical and policy support for payment systems 	Rural communities better adapted to climate variability and change due to diversified income portfolios derived from payment schemes for environmental services, and reduced carbon emissions from rural agricultural lands
Output Targets 2011	Evaluation of global, regional and national policies for GHG emission reductions in the context of enabling improved adaptation of rural communities (with Project 2)	<ul style="list-style-type: none"> Three regional policy analyses Recommendations for policy reform to promote synergies between adaptation and mitigation options 	Policy think tanks and researchers from national to global levels	New policy approaches adopted that provide incentives for PES	Policy options trialled by national governments
Output Targets 2012	Food-security-proofed payment schemes for environmental services established in pilot sites that work for marginalised groups, including women	<ul style="list-style-type: none"> Journal article on the institutional arrangements for payment schemes that address food security issues, especially for marginalised groups including female-headed households Major dissemination push to get results out, from national to global levels, taking advantage of the networks that already exist 	At global to regional levels: agencies dealing with global processes of UNCCD and IPCC; funding agencies investing in agricultural development and poverty reduction and climate change	Systematic technical and policy support for food-security-proofed payment systems	Rural communities better adapted to climate variability and change due to diversified income portfolios derived from payment schemes for environmental services, and reduced carbon emissions from rural agricultural lands

	Outputs	Verifiable Indicators of Output Targets	Intended Users	Outcomes	Impact
Output 3:	Tools, models and principles to enhance understanding of the trade-offs and synergies between mitigation and adaptation; and among the goals of environmental sustainability, reduced emissions and livelihood improvement		At global to regional levels: agencies dealing with global processes of UNCCD and IPCC; funding agencies investing in agricultural development and poverty reduction and climate change mitigation/adaptation; international development NGOs; regional agencies (e.g. SILSS, COMESA); agencies involved in markets for reduced emissions (inc. REDD); financial institutions providing finance for reduced emissions	<ul style="list-style-type: none"> ■ Adoption of adaptation and mitigation options that reduce the trade-offs and maximise the synergies ■ Systematic technical and policy support for combined adaptation–mitigation options 	Rural communities better adapted to climate variability and change due to diversified income portfolios derived from payment schemes for environmental services, and reduced carbon emissions from rural agricultural lands
Output Targets 2010	Analysis to determine how best to address the complex GHG mitigation, food security and livelihood issues associated with biofuels	<ul style="list-style-type: none"> ■ Commissioned set of specialist workshops ■ Policy briefs on implications of emerging biofuels markets on regional and local food security 	Researchers and think tanks dealing with biofuel production and its implications for poverty and the environment	New research directions identified and resourced	New mitigation options taken up
Output Targets 2011	Development of validated simulation models to assess trade-offs between targeted environmental goals of payment schemes, and food security and livelihood goals at the local to regional scale (with Projects 1, 2)	<ul style="list-style-type: none"> ■ Validated simulation models for carbon, livelihoods and environmental services ■ Journal article, policy brief and media release 	Research organisations dealing with trade-offs amongst adaptation and mitigation strategies, and trade-offs amongst the goals of emission reductions, environmental sustainability and livelihood outcomes	Models used to identify options that subsequently receive widespread testing	New mitigation options taken up
Output Targets 2012	Improved understanding of what makes win-win situations for improving rural income, food security and C sequestration	<ul style="list-style-type: none"> ■ Paper on the sequestration potential and economics of promising technologies with potential to reduce GHG emissions ■ Major dissemination effort, in concert with the UNCCD COP, to get results out 	Agencies dealing with global processes of UNCCD and IPCC; agencies investing in, and implementing, agricultural development and poverty reduction strategies and climate change mitigation and adaptation strategies	Systematic technical and policy support for combined adaptation–mitigation options; and options adopted by rural producers	Rural communities better adapted to climate variability and change due to diversified income portfolios derived from payment schemes for environmental services, and reduced carbon emissions from rural agricultural lands

Appendix 2. Acronyms and Abbreviations

ACMAD	African Centre of Meteorological Application for Development	IGBP	International Geosphere-Biosphere Programme (ICSU)
Aghrymet	A regional centre of CILSS – the Comité inter-Etats de lutte contre la sécheresse au Sahel – concerned with the collection and distribution of information that relates to food security and water management in the nine CILSS countries	IGFA	International Group of Funding Agencies for Global Change Research
AGM	Annual General Meeting (CGIAR)	IGP	Indo-Gangetic Plain
AGROPOLIS	Umbrella organisation of several agricultural research institutes in France	IHDP	International Human Dimensions Programme on Global Environmental Change (ICSU, ISSC, UNU)
AIACC	Assessments of Impacts and Adaptations to Climate Change (AIACC) in Multiple Regions and Sectors (START)	INRM	Integrated Natural Resource Management
AMMA	African Monsoon Multidisciplinary Analysis	IP	Intellectual Property
AR4	Fourth Assessment of the Intergovernmental Panel on Climate Change	IPCC	Intergovernmental Panel on Climate Change
ARI	Advanced Research Institute	IPG	International Public Goods
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa	IRI	International Research Institute for Climate and Society
AU	African Union	ISSC	International Social Science Council
CAS-IP	Central Advisory Service on Intellectual Property	IUBS	International Union of Biological Sciences (ICSU)
CCAFS	Climate Change Agriculture and Food Security (Challenge Program CGIAR-ESSP)	LIFE	Faculty of Life Sciences, University of Copenhagen
CGIAR	Consultative Group on International Agricultural Research	MDG	UN Millennium Development Goals
CILSS	Comité inter-Etats de lutte contre la sécheresse au Sahel	NARES	National Agricultural Research and Extension Institutes
COMESA	Common Market for Eastern and Southern Africa	NARS	National Agricultural Research Systems
CORAF/WE CARD	Conseil ouest et centre Africain pour la recherche et le développement agricole/West and Central African Council for Agricultural Research and Development	NGO	Non-Governmental Organization
CP	Challenge Program (CGIAR)	NRM	Natural resources management
CRM	Climate Risk Management	OASIS	Global agricultural research for development against dryland degradation and desertification
DANIDA	Danish International Development Agency	PIK	Potsdam Institute for Climate Impacts Research
DIVERSITAS	An International Programme on Biodiversity Science (ICSU, UNESCO, IUBS, SCOPE)	RCM	Regional Climate Models
ESSP	Earth System Science Partnership	REDD	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
FAO	Food and Agriculture Organization of the UN	RPG	Regional public goods
FARA	Forum for Agricultural Research in Africa	RWC	Rice–Wheat Consortium (CGIAR)
GCM	Global Climate Model also General Circulation Model	SCOPE	Scientific Committee on Problems of the Environment (ICSU)
GCP	Generation Challenge Programme	START	Global Change SysTEM for Analysis, Research and Training (ESSP)
GEC	Global Environmental Change	TPE	Target Populations of Environments
GECAFS	Global Environmental Change and Food Systems	UNESCO	United Nations Educational, Scientific and Cultural Organization
GEDIT	GEospatial Diagnostic Toolkit	UNFCCC	United Nations Framework Convention on Climate Change
GEO	Group on Earth Observations (GEOSS)	UNREDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
GEOSS	Global Earth Observing System of Systems	UNU	United Nations University
GHG	Greenhouse Gases	WFP	World Food Program
GTOS	Global Terrestrial Observing System		
ICPAC	IGAD Climate Prediction and Applications Centre		
ICSU	International Council for Science		
IGAD	The Intergovernmental Authority on Development (IGAD) in Eastern Africa		

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